Appendix A

Analysis of Groundwater Conditions at the Former Johnny M Mine, McKinley County, New Mexico (ITASCA, 2013)

ANALYSIS OF GROUNDWATER CONDITIONS AT THE FORMER JOHNNY M MINE MCKINLEY COUNTY, NEW MEXICO

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1.0 INTRODUCTION

Itasca Denver, Inc., (Itasca) was asked by Hecla Limited (Hecla) to review existing geologic, hydrogeologic, and geochemical data related to the former Johnny M Mine (Project Area) and surrounding area, located in McKinley County, New Mexico (Figure 1). Itasca was requested to address the following questions regarding potential groundwater and surface-water quality impacts associated with the Project Area:

- Is shallow groundwater quality in the Project Area affected by mine water during operations or leaching from mined materials?
- Has the groundwater quality of the former domestic wells in the Project Area (GMD-04 and/or GMD-05) or other groundwater resources been affected by mining-related activity in the Project Area?
- Is the quality of groundwater in the Project area affected by the presence of backfilled tailing sand in the underground workings?

The following sections provide a description of the geology, hydrogeology, and geochemistry of the Project Area and discuss Itasca's evaluation of these water-quality questions.

1.1 BACKGROUND

The Johnny M uranium deposit was discovered in November 1968 and work began on sinking a shaft in late 1972. Ore in the Johnny M Mine came from the Poison Canyon tongue of the Morrison Formation Brushy Basin Member and from a zone near the top of the Morrison Formation Westwater Canyon Member, at depths of between 1,300 and 1,400 feet below ground surface (ft bgs). Production appears to have started in 1976 with the shipment of low-grade ore to Kerr McGee's uranium mill located at Ambrosia Lake. No milling occurred on site; all ore was shipped off site for processing. Production at the mine ended in 1982.

The ore-bearing zone originally was saturated, and was dewatered to facilitate mining. Starting in August 1977, backfilling was performed to enhance the geomechanical stability of the stopes (areas of the mine from which ore had been produced). Approximately 286,000 tons of tailings sand were obtained from the Ambrosia Lake mill and placed within the mine to backfill stopes. Backfilling occurred using a mixture of mine-supplied water and sand, which was slurried into the stopes.

Initially mine discharges consisted of water resulting from dewatering and mine operations (e.g., drilling). Later, the slurry water was collected within the mine and pumped to land surface as part of the ongoing mine dewatering operations. (Mine water for purposes of this report includes water derived from groundwater dewatering, drill water, and slurry water.) Pumping from the mine averaged approximately 800 gallons per minute (gpm), and the recovered water was discharged to two treatment ponds that were excavated into native materials (Ponds 1 and 2 are shown in Figure 2). The recovered water was treated in the ponds by the addition of a coagulant and barium chloride, and then discharged to the San Mateo Creek drainage channel via a one-mile open ditch that was later replaced by a 12-inch diameter pipe (Figure 2).

The mine-water discharge plan, as described above, was approved by the New Mexico Environmental Improvement Board. The area to which treated-water discharge occurred is underlain by up to 80 ft of alluvium/colluvium on top of the Mancos Shale. During and after mining, water samples were collected from groundwater monitoring wells and surface-water locations. The locations of these sampling points are indicated in Figure 2. Figure 2 was constructed from three different hand-drawn maps; the locations of several sampling points are deemed approximate. Water samples collected at MW-1 represent the quality of the treated discharge waters from the surface-treatment ponds. A summary of the sampling points is provided in Table 1.

Upon completion of mining, the mine shaft was sealed with a reinforced four-foot-thick engineered concrete plug. The plug was set between the Dakota Formation and the Westwater Canyon Member of the Morrison Formation.

1.2 NEARBY PROJECTS AND OTHER DATA

In addition to the data that were available for the Project Area, the assessment provided in this report also considered data that were available from several nearby projects. A significant amount of geologic, hydrogeologic, and geochemical data were available from the Baseline Data Report (BDR) (Roca Honda Resources 2011) for the proposed Roca Honda (RH) mine that is located approximately one mile directly east of the Project Area (Figure 1). Data were also available from studies associated with the USDA Forest Service Non-Time Critical Removal Action (Science Applications International Corporation 1994) at the former San Mateo Mine that is located approximately two miles south of the Project Area. Geologic information in the Project Area was supplemented from a geologic log for one of the former domestic wells in the Project Area (GMD-04). Lastly, water-quality samples were collected from the two former domestic wells in the Project Area by the New Mexico Environmental Department (NMED) on behalf of the United States Environmental Protection Agency (USEPA) (NMED2011). The data available to Itasca were sufficient to answer the questions posed by Hecla.

2.0 GEOLOGY

2.1 REGIONAL GEOLOGY

The regional geology of the San Juan Basin is shown in Figure 1. The Project Area, the proposed RH permit area, and the former San Mateo Mine are also shown relative to the area depicted. Three structural features associated with the San Juan Basin (the Zuni uplift, Chaco slope, and Rio Grande Rift) are particularly important to the hydrogeology of the Project Area, as discussed below. The Zuni uplift is located approximately 25 to 30 miles southwest of the Project Area. This uplift is an important regional structural feature that exposes rocks as old as Precambrian in age and is an important location of regional recharge to groundwater. The area of transition from the Zuni uplift to the central part of the San Juan Basin is the Chaco slope (Figure 3), where regional sedimentary strata of mainly Mesozoic age dip gently to the northeast, into the central part of the basin. The dip of the rock units varies between four to eight degrees. The Rio Grande Rift is located on the southeast margin of the San Juan Basin and groundwater flow in the southeastern portion of the basin is generally directed toward this regional structural feature (Figure 3).

The stratigraphic column of geologic units encountered regionally is shown in Figure 4 and includes several units, such as the Menefee Formation, Point Lookout Sandstone, and Mount Taylor volcanics, that are not present in the Project Area due to an erosional unconformity.

2.2 SPECIFIC GEOLOGY OF PROJECT AREA

Understanding the geology and stratigraphy of the Project Area in relation to groundwater sampling activities, is critical to evaluating potential water-quality impacts to groundwater in the Project Area. Figure 5 is a stratigraphic column for the Project Area. It is particularly significant for answering two of the questions posed that some of the uppermost formations present regionally are not present in the Project Area, as they have been removed by erosion. Figure 5 also includes the stratigraphic locations of the screened zones for monitoring and domestic wells sampled for groundwater-quality investigations. The Gallup Sandstone is present in the Project Area, and it caps the mesas that occur within and in the vicinity of the Project Area; however, this sandstone is generally not saturated in the Project Area.

2.2.1 Surficial Sediments

In the Project Area, surficial sediments that are classified as alluvium or colluvium range in thickness from 0 to 80 ft. These sediments are typically thin and unsaturated near the mesas and become thicker and saturated near the San Mateo Creek drainage channel (Figure 2), a stream that flows intermittently.

2.2.2 Mancos Shale

As mentioned previously, the Menefee Formation and Point Lookout Sandstone do not exist in the Project Area because they have been eroded. As a result, the main body of the Mancos Shale is below the surficial sediments or the Gallup Sandstone. The Mancos Shale forms a widespread regional aquitard that is approximately 600 to 1,000 ft thick locally. The Mancos Shale represents the interplay of transgressive and regressive episodes of the epicontinental Western Interior Seaway. Shale, mudstone, claystone, and limestone were deposited during transgressions, and sandstones were deposited during regressions (Environmental Sciences Laboratory 2011). The Twowells Sandstone Tongue, an interbed of the Dakota Sandstone, occurs between the main body of the Mancos Shale and the Whitewater Arroyo Tongue of the Mancos Shale. One of the former domestic wells in the Project Area, GMD-04, which is located upgradient of the mine, appears to have been screened in this interbed within the Mancos Shale. Other localized sandstone lenses are also present within the main body of the Mancos Shale. As will be discussed later, the other former domestic well in the Project Area (GMD-05) is probably screened within the Mancos Shale.

2.2.3 Dakota Sandstone

The Dakota Sandstone is located below the Mancos Shale and was deposited during the initial transgression of the seaway, although, as previously noted, there is some interbedding between these formations. The Johnny M Mine potable groundwater-supply well (WW in Tables 1 and 2) was screened in the Dakota Sandstone (Figure 5). The Twowells Sandstone Tongue is the uppermost unit of the Dakota Sandstone and ranges in thickness from about 30 to 120 ft (Roca Honda Resources 2011), with an average thickness of approximately 70 ft. This is the uppermost bedrock water-bearing zone in the Project Area and, based on the depth of GMD-04 (depth to groundwater at 624 ft below top of casing and a total depth of 715 ft bgs), also appears to be the unit in which GMD-04 is screened. Below the Twowells Sandstone is another approximately 50 to 150 ft of Mancos Shale (the Whitewater Arroyo Shale Tongue), and below that is the 20 to 80 ft thick main body of the Dakota Sandstone. Based on the drilling log, well WW appears to be screened in the main body of the Dakota Sandstone (water level at a depth of 673 ft below top of casing and a total depth of 1,084 ft bgs).

2.2.4 Morrison Formation

The Morrison Formation is located below the main body of the Dakota Sandstone. The uppermost portion of the Morrison Formation is the Brushy Basin Member. Excluding the sandstone Poison Canyon Tongue at its base, the Brushy Basin Member is green shale with very low hydraulic conductivity (as evidenced by very slow draindown from the overlying Dakota Sandstone following dewatering of the Morrison Formation sandstones during mining (Rosel 1979)). The Brushy Basin Member averages about 100 ft thick in the local area. As previously mentioned, the Johnny M Mine recovered ore from sandstones in the Morrison Formation, namely the Poison Canyon Tongue, at the base of the Brushy Basin Member, and the subjacent (approximately 25 ft below) Westwater Canyon Member of the Morrison Formation, at depths of approximately 1,300 to 1,400 ft bgs. The mine was backfilled with tailings sand that was slurried into the mine workings in the Morrison Formation, and several water-quality sampling locations discussed below are within this zone (i.e., well 15, well 143, the North Vent pipe, UG4, UG5, UG6, DS2, and DN1; see Table 1; see also Figure 2 for locations of well 15, well 143, and the North Vent pipe).

3.0 HYDROGEOLOGY

3.1 REGIONAL HYDROGEOLOGY

In the San Juan Basin (including the Project Area), there are several thick, very low-permeability shale layers (e.g., the Mancos Shale, Brushy Basin Member of the Morrison Formation, and the Recapture Shale) that hydraulically separate the formations that serve as groundwater resources in the region. These shale layers separate the deeper groundwater resources (i.e., the Gallup Formation, Dakota Sandstone Formation, and Westwater Canyon Member of the Morrison Formation) from each other, as well as from the much shallower alluvial groundwater systems and shallow groundwater resource units (i.e., Point Lookout Sandstone and Menefee Formation) that are present regionally (INTERA 2012). Thus, recharge and discharge associated with these deeper units are a function of their outcrop exposures.

In general, groundwater recharge enters the groundwater-flow system as precipitation on permeable formations that crop out along the southern margin of the San Juan Basin and on the flanks of the Zuni, Chuska, and San Mateo mountains. Groundwater then flows downgradient, either northwestward to discharge along the San Juan River, or in the southeast portion of the basin (where the Project Area is located), northeastward, eastward, and southeastward (see Figure 3) toward the Rio Grande Rift, to discharge to tributaries of the Rio Grande, including the Rio Salado, Rio Puerco, and Rio San Jose. Potentiometric surface maps indicate that the pattern of regional groundwater movement within the deeper units in the southeastern part of the San Juan Basin is greatly influenced by the Zuni uplift, the Chaco slope, and the Rio Grande Rift (Roca Honda Resources 2011).

The movement of groundwater through the alluvial valleys is influenced by topography and surface-water drainages and is independent of—and sometimes flows in directions opposing—groundwater movement in the deep water-bearing units. Volcanic rocks of the Mt. Taylor volcanic field are present less than five miles to the east and south of the Project Area. This is an area of local and regional groundwater recharge for shallower rocks of the Tertiary and Upper Cretaceous age. The younger, shallower groundwater-bearing units in the region (e.g., the Menefee Formation and Point Lookout Sandstone) are not present in the Project Area. Where present regionally, these units occur higher in the stratigraphic sequence. The direction of groundwater flow for the shallow water-bearing unit in the region, the Menefee Formation (Figure 6), is to the northwest. The elevations of the water table (in the Menefee Formation) are approximately 600 to 700 ft above the potentiometric surface of the Westwater Canyon Member (cf. Menefee Formation and Westwater Canyon Member potentiometric contours in Figure 6). The higher potentiometric surface in the Menefee Formation indicates that there is a downward vertical gradient, and the vertical hydraulic gradient may be due, at least in part, to the low permeability of the Mancos Shale that separates alluvium and shallow water-bearing bedrock units from the deeper water-bearing units in the Project Area.

Other important regional water-bearing units, such as the Dakota Sandstone, are substantially deeper, moving away from the Project Area to the northeast. The Dakota Sandstone dips downward at an angle of 350 to 700 ft per mile to the northeast of the Project Area because of the dip associated with the Chaco slope. Accordingly, the geologic units present in the Project Area that could be considered groundwater resources, such as the Dakota Sandstone, are less desirable as a source of groundwater downgradient of the Project Area due to depth and the associated high costs of drilling and pumping water from deep wells. There are no identified domestic or stock wells completed in the Morrison Formation or Dakota Sandstone to the northeast of the Project Area. The distance of this well search is over ten miles from the mine. The nearest domestic wells in the general downgradient direction of the Project Area (wells 4, 7, 132, and 133 in Figure 7) are screened in the much shallower Menefee Formation or Point Lookout Sandstone. These wells are at least four miles northeast of the Project Area (Figure 7); furthermore, the hydraulic gradient in the vicinity of the Project Area is downward, away from the units in which these wells are screened. Figure 3 shows the basin-wide general regional pattern of deep groundwater flow in the Jurassic (Morrison Formation) and Cretaceous (Dakota Sandstone) water-bearing units (relevant to the Project Area) and Figure 8 shows the potentiometric surface and groundwater flow directions specific for the Westwater Canyon Member of the Morrison Formation in the southeastern portion of the San Juan Basin. As noted in Figures 3 and 8, groundwater flow in the deep Dakota Sandstone and Morrison formations is to the east-southeast based upon a regional analysis. Figure 6 shows that in the vicinity of the Project Area, deep groundwater flows to the northeast.

3.2 SPECIFIC HYDROGEOLOGY OF THE PROJECT AREA

3.2.1 Shallow Groundwater (Surficial Sediments)

Groundwater flow within the surficial sediments (alluvium and colluvium) that are located on the slopes and within the alluvial valleys follows the local topography (flow in the alluvium within the Project Area is generally to the west/southwest) in the opposite direction of groundwater flow in the bedrock (to the east/northeast). The alluvium is a source of groundwater to wells that are located near the San Mateo Creek drainage channel. The creek is also a source of groundwater recharge.

During mining operations, treated mine water was discharged from the ponds to a ditch and later to a pipe that eventually emptied into the San Mateo Creek drainage channel. A portion of this water, along with precipitation runoff, infiltrated these alluvial sediments and flowed to the San Mateo Creek drainage channel. Later, the pond water was piped farther down the slope, discharging at or near the San Mateo Creek drainage channel. Discharged water that infiltrated the surficial sediments would have perched on top of the Mancos Shale forming a saturated zone within the shallow surficial sediments; monitoring wells GW7, GW8, GW8A, and GW9 were installed and screened at the contact between the surficial sediments and the Mancos Shale (Figure 5) to monitor groundwater quality at this contact in response to discharges from the surface treatment ponds.

3.2.2 Intermediate Groundwater (Mancos Shale)

The hydraulic conductivity in the Mancos Shale is generally very low, on the order of 5 x 10^{-8} cm/s (Roca Honda Resources 2011). To put this value into context, a compacted clay liner for a municipal landfill typically has a permeability (hydraulic conductivity) of approximately 1 x 10^{-7} cm/s (Benson and Trast 1995). Isolated sandstone lenses typically occur within the Mancos Shale (Environmental Sciences Laboratory 2011) and have been noted in drill logs from the Project Area. For example, 'gray sandstone' was noted in the geologic log at 115 to 130 ft bgs from a former domestic well within the Project Area located upgradient of the mine (OSE#B-01544, subsequently identified as GMD-04) within the 615 ft thick Mancos Shale interval. The well log for the other well at the former residence located upgradient of the mine, GMD-05, was not available for evaluation. It was noted though that GMD-04 was drilled as a replacement because

GMD-05 failed to produce water at sufficient rates (T. Jackson, pers. comm. with M. Schierman of ERG). As discussed below, the quality of groundwater from GMD-05 also appears similar to that reported elsewhere for the natural groundwater quality associated with the Mancos Shale.

3.2.3 Deep Groundwater (Dakota Sandstone and Morrison Formation)

The hydraulic conductivity of the Dakota Sandstone ranges from 9 x 10^{-5} to 5 x 10^{-4} cm/s (INTERA 2012). The hydraulic conductivity values for the Dakota Sandstone suggest that it is capable of transmitting low to moderate volumes of water depending on its thickness. Wells producing from the Dakota Sandstone yield in the range of 1 to 75 gpm with a median value of 12 gpm (Roca Honda Resources 2011).

The hydraulic conductivity of the Westwater Canyon Member varies from 7 x 10^{-6} to 6 x 10^{-4} cm/s (INTERA 2012). These values suggest that the Westwater Canyon Member transmits low to relatively high quantities of water, again, depending on its thickness. Wells completed in the Westwater Canyon Member have been pumped at rates between 10 and 560 gpm with typical values around 100 gpm (Roca Honda Resources 2011). As noted in Figure 6, the direction of flow for groundwater in the Project Area in the Westwater Canyon Member is towards the north-northeast.

The hydraulic gradient calculated from the potentiometric surface map for the Westwater Canyon Member shown in Figure 6 is approximately 0.024 ft/ft to the northeast. Assuming an effective porosity of 0.1 (Roca Honda Resources 2011) yields a range of groundwater velocities of 2 to 150 ft per year in the Westwater Canyon Member. Based upon this range of values, it would take groundwater approximately 35 to 2,600 years to travel one mile. Assuming the hydraulic gradient of 0.024 ft/ft, the elevation of the potentiometric surface would be at an elevation of approximately 5,350 ft above mean sea level in the vicinity of well 133 (Figure 7), a well screened in the Menefee Formation. The elevation of the bottom of this well is approximately 6,760 ft (Roca Honda Resources 2011). This means that there is approximately 1,200 ft of separation between groundwater in the Morrison Formation and the Menefee Formation.

4.0 GROUNDWATER QUALITY

The available groundwater-quality data related to the Project Area were compiled by Itasca and are provided in Table 2 and discussed below.

The assessment of potential past and future groundwater impacts resulting from historical mining operations hinges on the potential migration of uranium (U) in groundwater. The following paragraphs provide an overview of the geochemistry of U and its potential to migrate in groundwater.

Uranium movement in groundwater is dependent upon the geochemical conditions of the environment, particularly with respect to pH and oxidation state (i.e., Eh). Uranium in an oxidizing environment is capable of migrating with groundwater, unlike in reducing conditions such as those found in groundwater in the Dakota Sandstone and Morrison Formation in the Project Area. Figure 9 shows an Eh-pH diagram for the simplified geochemical system composed of U, silica, and water at 25°C. Minerals such as coffinite ($USiO_4$) illustrated in Figure 9 and uraninite [UO_2(a)]—which occupies a similar but smaller stability range to that illustrated for coffinite in Figure 9—contain U in its reduced form, the U(IV) valence state, and are relatively insoluble and stable under reducing conditions. Whereas, the mineral schoepite [$UO_2(OH)_2 \bullet H_2O$] (Figure 9) contains U in the U(VI) valence state. The U(VI) valence state is predominant in more oxidizing conditions, such as those frequently associated with surface water and shallow groundwater. It is often present as a UO_2^{+2} ion or associated hydroxide and/or carbonate complexes. Unlike the U(IV) valence state that is predominant in more reducing conditions, the uranyl hydroxide and/or carbonate complexes can increase U migration in groundwater relative to U(IV). Furthermore, the mineral schoepite, which forms in more oxidizing conditions, is more soluble than the minerals coffinite and uraninite that form under more reducing conditions. Accordingly, the solubility of U minerals also contributes to the ability of U to migrate in oxidizing conditions typically associated with surface water and shallow groundwater.

Radium is generally not of concern in the Project Area based upon work conducted by the NMED (NMED 2010). The NMED indicated in a review of geochemistry in the San Mateo Creek (SMC) area that:

> [Radium] Ra does not appear to be a contaminant of concern in the ground water system of the SMC study area because it is relatively insoluble, does not tend to form soluble complexes with other ions, was easily precipitated out of acidic mill tailings by the addition of $BaSO_4$, and has a strong tendency to adsorb onto various mineral surfaces such as clays and other silicate minerals (Landa, 1980). Based on the water sample results from EPA, 1975, and the results from this investigation, Ra does not appear to be a radiochemical of concern or a reliable indicator of legacy U mining and milling impacts.
>
> In contrast, U concentrations from this investigation indicate that this radionuclide is elevated in the ground water, and the geochemical conditions support transport of this metal in the aqueous environment.[1, 2]

The NMED (2010) concluded that the estimated average U concentration in groundwater samples that are assumed not to be impacted by mining or milling discharges is less than 5 µg/L.

4.1 SHALLOW GROUNDWATER QUALITY

4.1.1 Shallow Groundwater-Quality Observations

Shallow groundwater, when present, is separated from the deeper Dakota Sandstone Formation and Morrison Formation water-bearing zones by more than 600 ft of relatively impermeable (Mancos) shale. Hence, the mining activities in the Project Area with the potential to have affected the quality of shallow groundwater were the surface activities associated with discharging mine water into the ponds/ditch and the potential for leaching of stockpiled mine-related materials on the land surface.

During infiltration events in the Project Area, surface water infiltrates downward and perches temporarily on the bedrock (Mancos Shale) surface before it moves downgradient.

Potential degradation of shallow groundwater from the above activities is evaluated below by comparison of the water quality associated with dewatering water, sand slurry, shallow

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[1] Note that $BaCl_2$ was used for water-quality treatment at the Johnny M Mine. This forms an insoluble $BaSO_4$ co-precipitate that quantitatively removes radium.

[2] The NMED text cited here is in reference to surficial, oxidizing conditions. Uranium is much less soluble and mobile under reducing conditions, such as those in the Johnny M Mine following inundation by groundwater at the end of mining.

groundwater monitoring wells, and well(s) located on a nearby ranch. As illustrated in Figure 5, the shallow groundwater monitoring wells located within the Project Area were typically constructed to collect water from the contact between the surficial sediments and the top (weathered surface) of the Mancos Shale. Weathered zones of the Mancos Shale have been noted as being naturally affected by geochemical processes including pyrite oxidation, carbonate dissolution, gypsum precipitation, release of nitrate from weathering of organic material, and solubilization of U (Environmental Sciences Laboratory 2011). Consistent with these processes, Figure 10 illustrates that the sulfate concentrations observed in the shallow groundwater monitoring wells (GW7, GW8A, and GW9) are actually higher, in most cases, than the concentrations observed in sand slurry (MWS-3), dewatering discharge, and MW-1 (which was the monitoring location for discharge from the pipeline or ponds prior to entry into the San Mateo Creek drainage channel), or any of the water-quality samples collected from within the underground mine (e.g., DN1, DS2, UG4, UG5, UG6, North Vent pipe).

Similarly, Figure 11 illustrates the nitrate and U concentrations from shallow groundwater wells, the upgradient wells (former domestic wells) within the Project Area, sand slurry, and various mine-water samples. The shallow groundwater-well samples generally cluster around the U and nitrate geometric mean for the Mancos Shale, but with slightly lower U concentrations. In contrast, U concentrations in mine waters are typically an order of magnitude higher than those observed in the shallow groundwater monitoring wells, and the nitrate concentrations are typically one to three orders of magnitude lower in mine waters than in the shallow groundwater monitoring wells.

Water chemistry was measured in 1993 in a groundwater sample from a well located on the Marcus Ranch, which is a shallow groundwater well located on the north side of the San Mateo Creek drainage channel and downgradient of the former Johnny M Mine discharge location (Figure 2). The gross alpha concentration (activity) was 6±15 pCi/L, the ^{226}Ra concentration was 0.20±0.28 pCi/L, the gross beta concentration (activity) was 7±29 pCi/L, the dissolved U was 3.5 µg/L, arsenic was less than 0.005 µg/L, lead was less than 0.01 µg/L, molybdenum was less than 0.02 µg/L, selenium was less than 0.01 µg/L, and vanadium was less than 0.01 µg/L. In summary, concentrations of U, ^{226}Ra, arsenic, lead, molybdenum, selenium, and vanadium were either below detection limits or below drinking water-quality standards (Science Applications International Corporation 1994).

4.1.2 Conclusions Regarding Potential Impacts to Shallow Groundwater Quality

Mining-related discharge water that infiltrated the shallow surficial sediments and perched on the surface of the Mancos Shale more than 25 years ago as a result of mining activities would not now be contributing seepage to the San Mateo Creek drainage system. Subsequent overland runoff and infiltration over the past 25 years would have concentrated in drainage features and tended to 'flush' sediments. Given that the runoff waters would be rich in dissolved oxygen, this oxygenated water would have mobilized any U, or 'flushed' any U from the sediments.

The groundwater quality measured in a water sample from the Marcus Ranch well indicated that the water-bearing surficial sediments have not been impacted by the historical discharges from the mine or by the current conditions within the Project Area. Whereas the other radionuclides (alpha and gross beta) had large errors surrounding the measured concentrations, the reported concentrations do not indicate impacts, particularly when considered together with the low concentrations of U, ^{226}Ra, and other metals typically associated with mine water.

4.2 INTERMEDIATE GROUNDWATER QUALITY

4.2.1 Intermediate Groundwater-Quality Observations

The groundwater-quality compositions of the two upgradient wells (former domestic wells) within the Project Area (GMD-04 and GMD-05) are quite different from one another. The results of groundwater analyses for wells GMD-04 and GMD-05 are shown in Table 2. The quality of groundwater from GMD-04 can be summarized as follows:

- a mixed calcium/sodium-bicarbonate/sulfate water type;
- at or near the USEPA human health-based maximum contaminant limit (MCL)[3] for gross alpha (17.3±4.01 picocuries per liter (pCi/L) vs. MCL of 15 pCi/L); there is no applicable State standard[4] for gross alpha for groundwater;
- at or near the MCL for radium radioactivity (3.33±1.15 pCi/L for ^{226}Ra plus 2.67±0.75 pCi/L for ^{228}Ra vs. MCL of 6.0 pCi/L combined), although this is substantially less than the applicable State standard of 30 pCi/L for radium in groundwater;

[3] USEPA primary MCL (includes both safety factors and lifetime exposure scenarios) and secondary MCL (addressing aesthetic quality) values.

[4] State standards for groundwater are the New Mexico Water Quality Control Commission (NMWQCC) standards, which are applicable to domestic water supply.

- exceeds the secondary MCL for manganese (68.1 micrograms per liter (µg/L) vs. secondary MCL of 50 µg/L); there is no applicable State standard for manganese in groundwater;
- exceeds the secondary MCL for sulfate (270 milligram per liter (mg/L) vs. secondary MCL of 250 mg/L); although this is substantially less than the applicable State standard of 600 mg/L for sulfate in groundwater; and
- exceeds the secondary MCL for total dissolved solids (TDS) (709 mg/L vs. secondary MCL of 500 mg/L); although this is substantially less than the applicable State standard of 1,000 mg/L for TDS in groundwater.

In summary, GMD-04 exceeds secondary MCL values for manganese, sulfate, and TDS and the primary standard for gross alpha.

In comparison, the groundwater quality from well GMD-05 can be summarized as follows:

- a sodium-chloride water type;
- exceeds the secondary MCL and State standard for chloride in groundwater (1,500 mg/L vs. secondary MCL and State standard of 250 mg/L);
- exceeds the secondary MCL for sulfate (280 mg/L vs. secondary MCL of 250 mg/L), although this is substantially less than the State standard of 600 mg/L for sulfate in groundwater; and
- exceeds the secondary MCL and State standard for TDS in groundwater (3,070 mg/L vs. secondary MCL of 500 mg/L and State standard of 1,000 mg/L).

In summary, GMD-05 exceeds applicable secondary MCL and State groundwater-quality standards for chloride and TDS. As previously mentioned, this well does not produce sufficient rates of water flow for use as a domestic well.

As noted previously, well GMD-04 appears to be screened in the upper portion of the Dakota Sandstone (the Twowells Sandstone Tongue). The water quality of the Dakota Sandstone was characterized in the Marquez, New Mexico area by Daniel B. Stephens and Associates, Inc. (DBSA 2008), who provided the following description:

> The Dakota Sandstone is a sodium-bicarbonate water type near recharge areas with increasing sulfate concentrations downgradient (Dam 1995). Water quality in the Dakota Sandstone is variable and generally acceptable for domestic, livestock, and industrial use (Dam 1995). In some areas the

groundwater has elevated TDS and sulfate concentrations that exceed standards (Table 4). Trace elements that were detected at concentrations above standards include iron and manganese (Table 5).

The TDS, sulfate, and manganese water quality exceedances reported for the Dakota Sandstone are consistent with the groundwater quality observed in GMD-04. Gross alpha and radium radioactivity were not reported by DBSA for the Dakota Sandstone; however, the Dakota Sandstone has been reported as a host for low grade U deposits in the Grants Mineral Belt (Green 1980). In fact, U concentrations in the Dakota Sandstone measured in the Johnny M Mine water well in January 1973, prior to the initial mine shaft reaching the ore zone, were 340 µg/L, which would typically equate to a gross alpha of more than 200 pCi/L.

The chemistry of groundwater samples from GMD-05 is generally consistent with background groundwater quality in the Mancos Shale. Figure 10 illustrates the chloride and sulfate concentrations for groundwater samples from GMD-04 and GMD-05, the ranges (minimum, maximum, and geometric mean) observed in water samples from the Mancos Shale regionally (Environmental Sciences Laboratory 2011), and from groundwater, surface water (e.g., MW-1 in Table 2), and mine water collected in the Project Area. Note that the chloride concentrations (which, together with sodium comprise the majority of the dissolved constituents) in GMD-05 are higher than for any of the other waters in the Project Area and this well is located vertically and laterally upgradient of the former Johnny M Mine. Of the water-quality samples included in Figure 10, only groundwater from the Mancos Shale (regionally) has chloride concentrations as high as those observed in GMD-05. There is a lower proportion of sulfate relative to chloride observed in GMD-05 (in comparison with the Mancos-Shale trend), which could be an artifact of locally reducing conditions (that would also account for the low dissolved U and metals in water from this well), or could be a result of limited availability of deeper-water samples from the Mancos Shale (because groundwater wells are not typically completed in the Mancos Shale). However, it has been noted that groundwater from deep (greater than 27 m below ground surface) wells in the Mancos Shale have “a sodium chloride composition, in stark contrast to the sulfate-dominated water in shallow, more weathered horizons” (Morrison et al. 2012).

4.2.2 Conclusions Regarding Potential Impacts to Intermediate Groundwater Quality

Uranium concentrations in GMD-04 and GMD-05 are 3 µg/L and <2 µg/L, respectively, as presented in Section 4.0, which, as noted previously, are not indicative of mining-related impacts (NMED 2010).

The horizontal hydraulic gradients within the Dakota Sandstone and Morrison Formation are northeastward/eastward, away from the Project Area so that potential water-quality impacts within the Dakota Sandstone and lower units would migrate away from the former domestic wells in the Project Area. Lastly, approximately 600 ft of relatively impermeable shale (Mancos Shale) separates former surface operations from the screened interval of GMD-04. The groundwater quality observed in GMD-04 is consistent with naturally occurring conditions in the Dakota Sandstone and is not indicative of legacy U mining impacts.

Impacts from mine water cannot account for the groundwater quality observed in well GMD-05 because this well is upgradient of the Morrison Formation and Dakota Sandstone groundwaters in the Project Area, and water from this well has higher concentrations of chloride than any of the mine waters. Well GMD-05 appears to be representative of naturally occurring poor groundwater quality in a geologic unit of low transmissivity, most likely the Mancos Shale. The groundwater quality of these upgradient wells (former domestic wells) within the Project Area is unrelated to mining activity; therefore, the water-quality analysis from these wells should not be used for evaluating the question of whether shallow groundwater quality in the Project Area is impacted as a result of past mining activities.

4.3 DEEP GROUNDWATER QUALITY

4.3.1 Deep Groundwater-Quality Observations

Water quality in the underground workings at the Johnny M Mine was monitored prior to and during backfilling with a sand slurry that started in August of 1977 and was completed sometime prior to cessation of mining activity in 1982.

Figure 12 illustrates the water quality of various groundwater, mine-water, and surface-water samples compiled from various sources (see also Table 2). The actual water-quality parameters analyzed differ somewhat between sampling events due to the differing objectives of the various sampling events. The earliest data illustrated in Figure 12 are groundwater samples from the Dakota Sandstone during development of the initial mine shaft prior to any ore mining. There are numerous sampling data during backfill placement. In terms of subsequent monitoring, a sample was collected from the North Vent pipe in 1985, and the NMED conducted sampling of the upgradient former domestic wells in the Project Area. The North Vent pipe is a sampling point at the former ventilation shaft of the Johnny M Mine used to sample groundwater quality in the backfilled mine (Westwater Canyon Member). Additional sampling of the groundwater quality in the Morrison Formation that hosts the backfilled underground workings (e.g., wells 15 and 143) has recently been conducted as part of baseline water-quality evaluations being conducted for the proposed Roca Honda Project (Roca Honda Resources 2011). The North Vent pipe, well 15, and well 143 draw groundwater from the Westwater Canyon Member of the Morrison Formation.

As illustrated in Figure 12, the sand-slurry water (MSW-3) had elevated concentrations of various constituents (i.e., arsenic, nitrate, molybdenum, selenium, vanadium, gross alpha, radium, thorium, U, chloride, sulfate, and TDS) as compared to the other water samples. Water samples were collected 26 times at location MSW-3 from September 1977 to December 1978 (Table 2). Although the sand-slurry water contained notably elevated concentrations of some water-quality constituents, that water was removed from the mine after the backfill was deposited. Mine-water samples illustrated a much smaller and temporary increase in some constituents during and/or immediately following backfill placement, but the subsequent analyses of water quality within and near the mine (North Vent pipe, well 15, and well 143) all indicate that the groundwater quality in the Morrison Formation has since returned to background concentrations as represented by analyses of groundwater samples from the aforementioned locations. The concentrations of these constituents observed in the underground workings were much lower as a result of immobilization under the circumneutral and reducing conditions of ambient groundwater. On the other hand, the slurry water was initially oxidizing and in some cases mildly acidic. In addition, the slurry water was pumped from the mine, treated, and discharged.

The 1985 sample from the North Vent pipe indicated the following concentrations in groundwater at a depth within the backfilled mine: arsenic was 0.011 mg/L; molybdenum was 0.3 mg/L; selenium was <0.005 mg/L; vanadium was <0.1 mg/L; chloride was 11.9 mg/L; sulfate was 205 mg/L, TDS was 495 mg/L; and nitrate, gross alpha, radium, thorium, and U were not reported. The water-quality parameters measured either met water-quality standards that existed at the time or reflected natural groundwater conditions.

In the most recent sampling event for well 143 (September 23, 2010), all constituents either meet USEPA public drinking water system standards or are similar to background concentrations. Specifically, arsenic, nitrate, selenium, molybdenum, and vanadium are all below limits of detection; gross alpha radiation is 6 pCi/L, radium (226 plus 228) is 4.9 pCi/L, thorium (230) is 0.5 pCi/L, and U is 3.2 µg/L, chloride is 18 mg/L, sulfate is 276 mg/L, and TDS is 737 mg/L. For comparison, the geometric mean of sulfate and TDS concentrations in the Westwater Canyon Member of the Morrison Formation (based on 48 samples from the nearby area) is 425 and 1,047 mg/L, respectively (Roca Honda Resources 2011).

Similarly, recent sampling events for well 15 indicated that all of these constituents meet USEPA public drinking water system standards. Specifically, arsenic, nitrate (with the exception of one sample reported at the detection limit of 0.1 mg/L), selenium, molybdenum, vanadium, and U are all below detection; gross alpha radiation is less than or equal to 3.4 pCi/L, radium (226 plus 228) is less than or equal to 1.62 pCi/L, thorium (230) is less than 0.2 pCi/L, chloride is less than or equal to 9 mg/L, sulfate is less than or equal to 181 mg/L, and TDS is less than or equal to 591 mg/L. Well 15 is located east of the former Johnny M Mine and, for deeper groundwater, could represent a downgradient sampling point from the mine.

4.3.2 Conclusions Regarding Potential Impacts to Deep Groundwater Quality

Backfilled sand that was placed into the Johnny M Mine are unlikely to impact deep groundwater quality because

1) the slurry water was removed from the mine immediately following placement of the backfill, and

2) the materials used (or considered for use) in backfilling operations in the Grants Mineral Belt (Thomson and Heggen 1982; Thomson et al. 1986), and at Johnny M Mine specifically (Gamble 1992), were largely devoid of the finer particles (e.g., clays) that carry the majority of the leachable/reactive metal content (Thomson and Heggen 1982; Thomson et al. 1986).

Removal of the fine material (e.g., clay) was an important consideration in the use of the sand for placement. Sand was used as backfill material because it was easier to transport and to handle within the mine. Also, the use of sand as backfill was driven by safety concerns, i.e., 'unsized tailings' material would not drain properly and could cause a potentially dangerous 'muck rush' condition within the mine. The finer particles (e.g., clays), less than 200 mesh, contained the majority of the leachable reactive load (Thomson et al. 1986), and this material was retained at the Ambrosia Lake mill and tailings facility. These facilities were not located in the Project Area. Thus, the removal of the fines (e.g., clay) substantially reduced the amount of leachable constituents, including metals, the metalloids such as arsenic (As) and selenium (Se), and sulfate (SO_4). Analyses described in Thomson et al. (1986), and summarized in Thomson's Tables 3 and 4 (see below), indicate the difference in compositions for the sand and clay fractions from undisclosed operations in the Grants Mineral Belt. The tables show that large enrichment factors are present, with the fine (e.g., clay) fraction always showing enrichment relative to the sand fraction.

Table 3. Average concentrations in each fraction of backfilled sands, determined by INAA (9 samples)

Element	Sand (ppm)	Clay (ppm)	Water* (mg/l)	Enrichment Clay/Sand
Al	35633.3	66800.0	3.3	1.9
As	3.16	18.47	0.12	5.8
Ba	695.8	945.8	0.0	1.4
Ca	2362.2	32887.8	323.9	13.9
Cr	10.4	317.9	0.2	30.7
Fe	2081.6	25994.4	7.8	12.5
K	22366.7	25855.6	228.5	1.2
Mg	0.0	3173.3	0.0	17.5
Mo	10.2	178.6	0.3	17.5
Se	8.24	80.31	0.90	9.8
Th-223	1.828	7.513	0.002	4.1
U-239	29.27	226.41	0.70	7.7
V	82.4	928.8	0.6	11.3

* Concentrations in 250 ml of solution containing 100 g of backfilled sands.

Table 4. Average concentrations in each fraction of acid-leach uranium. mill tailings by INAA (2 samples)

Element	Sand (ppm)	Clay (ppm)	Water* (mg/l)	Enrichment Clay/Sand
Al	37850.0	60050.0	0.0	1.6
As	2.51	20.44	0.17	8.2
Ba	778.5	642.0	0.0	0.8
Ca	2775.0	41150.0	470.1	14.8
Cr	9.88	157.30	0.0	15.9
Fe	2387.5	30370.00	11.5	12.7
K	23500.0	25400.0	64.9	1.1
Mg	0.0	2650.0	0.0	
Mo	5.39	216.00	0.0	40.1
Se	8.17	124.10	0.13	15.2
Th-223	1.172	2.488	0.0	2.1
U-239	19.04	118.35	0.10	6.2
V	169.45	954.00	0.69	5.6

* Concentrations in 250 ml of solution containing 100 g of acid-leach uranium mill tailings.

Note: Tables 3 and 4 were copied directly from the original peer-reviewed paper. However, the Th-223 values reported may actually represent Th-233, which is derived from neutron activation of Th-232 (used in instrumental neutron activation analysis [INAA]).

In addition to the fact that sand, rather than fines, was utilized in backfilling, the geochemical conditions in the backfilled mine act to limit solubility and thus the potential for metals migration.

Over the last 15 to 20 years, subaqueous disposal of tailings has been employed at numerous mining operations to limit the formation of acid-rock drainage and the subsequent leaching of metals. The mitigation of acid and metals leaching by subaqueous disposal is due to the slow rate of diffusion of oxygen through water relative to air; a water cover is used primarily to halt pyrite oxidation and subsequent acid-rock drainage in the near surface (MEND 2001). Molecular oxygen is the primary driver for oxidation reactions involving pyrite (FeS_2). Upon the cessation of dewatering, groundwater collecting in the Johnny M Mine would behave similarly, with backfilled sand and other minerals in the mine environment stabilized by the reducing conditions. Limited access of oxygen and the presence of organic matter (mainly humic materials present in the Westwater Canyon Member), which would consume any small amounts of residual oxygen, produces a reducing environment (low Eh) that would stabilize U and other constituents as mineral solids, immobilizing them in the deep groundwater system.

For example, the insoluble minerals uraninite and coffinite are stable under reducing conditions (Figure 9), where the presence of electrons donors, such as humic substances, result in low Eh values. Furthermore, the U^{+4} ion that is predominant in these conditions does not have a strong tendency to form aqueous complexes that could increase the concentration of U in solution; rather, the U^{+4} ion tends to form mineral precipitates such as uraninite or coffinite.

The geochemical conditions in the mine after mining was completed and the mine became resaturated are expected to have returned to conditions similar to those that were present prior to mining (i.e., reducing conditions that were responsible for the precipitation of the U(IV) minerals that formed the original ore deposit). These reducing conditions have re-stabilized elements, such as U, that were associated with the ore deposit or backfilled sand. The Johnny M deposit formed under reducing conditions in sediments that were rich in humic materials (derived from plant matter) that allowed for the precipitation of U, which was introduced by periodic volcanic episodes (Falkowski 1980). Thus the distribution of U was influenced directly by the volcanic episodes. It is expected that without exposure to atmospheric oxygen, humic material and other organic matter still present in the geologic materials near the mine, together with reduced minerals such as authigenic pyrite (FeS_2) and jordisite (MoS_2), will continue to support a low Eh environment in and near the mine workings. Dissolved U will precipitate either as coffinite or as uraninite, thus limiting both concentrations and mobility in groundwater.

Redox conditions that limit U mobility are consistent with studies in the general area and with groundwater quality observations in the Project Area. Thomson and Heggen (1982) discuss several redox related processes and estimate the native groundwater to be within a pH range of 6 to 8, with a maximum Eh of approximately 0.17 volts (at a pH of 6), and a minimum Eh of approximately -0.12 volts (pH 8). In Thomson et al. (1986) the authors showed an ore zone region that suggested even lower Eh conditions are possible. These ore zone conditions have Eh values as low as -0.28 volts. These lower conditions are near the boundary between 'organic' carbon and inorganic carbon. This region is also within the boundary between sulfide and sulfate. In addition to the abundant humic materials, the ore zones also contain authigenic (formed in place) pyrite (Falkowski 1980), which will drive redox conditions toward an ore-formation or pre-mining Eh. As discussed below, these organic and sulfide rich, low Eh conditions in the backfilled and saturated Johnny M Mine are apparent from the notable decreases in concentrations of elements such as arsenic, radium, selenium, thorium, U, and vanadium that have occurred subsequent to cessation of dewatering activities in 1982 (Figure 12). The assumptions used by Thomson et al. (1986) to define the Eh-pH region of the Morrison Formation subsequent to mining appear to be a reasonable and appropriate representation for groundwater in the ore zones in the Project Area. Accordingly, under reducing conditions, such as in the deep groundwater in the Dakota Sandstone and Morrison Formation at the Johnny M Mine, U is relatively immobile and has low aqueous concentrations.

In summary, there is no indication that the mine activities have negatively affected groundwater quality in or downgradient of the underground workings at the Johnny M Mine. Water quality at Johnny M Mine and other backfilled underground U mines in the Grants Mineral Belt are similar to their mine water quality prior to backfilling. At the Johnny M Mine, the nearby groundwater wells that provided water samples from depths similar to the mine workings (e.g., wells 15 and 143, and the North Vent pipe) have solute concentrations similar to background conditions. These results are consistent with expected U geochemistry; U is mobile in surficial, oxidizing conditions, but is immobile in the reducing conditions present within the Dakota Sandstone and Morrison Formation in the Project Area.

5.0 SUMMARY AND CONCLUSIONS

Itasca was asked by Hecla Limited to analyze existing hydrogeologic data relevant to conditions at the former Johnny M uranium mine that is located in McKinley County, in northwestern New Mexico. The former mine is located within a historic uranium mining district referenced as the Ambrosia Lake uranium mining district. Mining of ore occurred at the Johnny M Mine from approximately 1976 until 1982 when operations ceased.

Hecla Limited had the following questions that Itasca was to address in its analysis:

- Question 1: Is shallow groundwater quality in the Project Area affected by mine water during operations or leaching from mined materials?
- Question 2: Has the groundwater quality of the former domestic wells in the Project Area (GMD-04 and/or GMD-05) or other groundwater resources been affected by mining-related activity in the Project Area?
- Question 3: Is the quality of groundwater in the Project Area affected by the presence of backfilled tailing sand in the underground workings?

Itasca reviewed the analyses of mine-water, groundwater, and surface-water samples collected during and immediately after mining, as well as samples collected recently by NMED and other contractors working in the nearby area. In addition, a significant amount of data regarding the geology, hydrogeology, and geochemistry of the area surrounding the former Johnny M Mine are available from the Baseline Data Report and other reports generated by or for the proposed Roca Honda Mine that is located approximately one mile east of the former Johnny M Mine.

Based upon Itasca's review and analysis of the existing data, Itasca offers the following conclusions.

Answer to Question 1

Shallow groundwater quality was measured historically in three former groundwater monitoring wells that were located downgradient of the mine-water discharge pathway through the ditch and upgradient of the San Mateo Creek drainage channel. The shallow groundwater monitoring wells were located and screened to collect groundwater samples from the contact between the surficial sediments and the top (weathered surface) of the Mancos Shale. Weathered zones of the Mancos

Shale have been noted as being naturally affected by geochemical processes, including pyrite oxidation, carbonate dissolution, gypsum precipitation, release of nitrate from weathering of organic material, and solubilization of U. Consistent with these processes, the sulfate concentrations observed in the shallow groundwater monitoring wells (GW7, GW8A, and GW9) were actually higher than the concentrations observed in sand slurry water, dewatering discharge or any of the water-quality samples collected from within the underground mine. The shallow groundwater well samples generally cluster around the U and nitrate geometric mean for the Mancos Shale, but with slightly lower U concentrations. In contrast, U concentrations in discharged (treated) mine waters were typically an order of magnitude higher than those observed in the shallow groundwater monitoring wells, and the nitrate concentrations were typically one to three orders of magnitude lower in discharged (treated) mine waters than in the shallow groundwater monitoring wells.

In addition to having groundwater quality that was substantially poorer due to natural conditions (e.g., higher concentrations of sulfate, nitrate, chloride, and TDS) than that associated with mine activities, the shallow groundwater system is transient. During infiltration events, surface water will infiltrate downward and perch on the bedrock (Mancos Shale) surface temporarily. However, the surficial sediments are typically unsaturated and the Mancos Shale is an aquitard. There is no indication that any water that infiltrated the shallow surficial sediments and temporarily ponded on the surface of the Mancos Shale as a result of mining activities more than 25 years ago is contributing seepage to the San Mateo Creek drainage channel or to underlying water-bearing units today. Subsequent overland runoff over the past 25 years would have concentrated in the ditch and tended to have 'flushed' any surficial sediments. Given that the runoff waters would probably be rich in dissolved oxygen, this oxygenated water would have mobilized U, or 'flushed' any U from the surficial sediments.

Water chemistry measured in a shallow groundwater well located on the north side of the San Mateo Creek drainage channel and downgradient of the former Johnny M Mine discharge location (Marcus Ranch well) indicated that the water-bearing surficial sediments have not been impacted by the historical discharges from the mine or by the current conditions within the Project Area. Concentrations of U, ^{226}Ra, arsenic, lead, molybdenum, selenium, and vanadium were either below detection limits or below drinking water standards. Whereas the other radionuclides (alpha and gross beta) had large errors surrounding the measured concentrations, the reported concentrations do not indicate impacts, particularly when considered together with the low concentrations of U, ^{226}Ra, and other metals typically associated with mine water.

Answer to Question 2

The former domestic wells in the Project Area are located upgradient of the former Johnny M Mine (and associated mining activities) and are screened at intermediate depths, either within an upper interbed of the Dakota Sandstone Formation (GMD-04) or within the Mancos Shale (GMD-05). The quality of the groundwater samples collected from these wells is reflective of natural background conditions encountered in these two formations. The groundwater quality observed in well GMD-04 is consistent with naturally occurring conditions in the Dakota Sandstone and is inconsistent with legacy U mining impacts. The groundwater quality observed in well GMD-05 appears to be representative of naturally occurring poor groundwater quality in a low transmissivity geologic unit, most likely the Mancos Shale. Impacts from mine water cannot account for the groundwater quality observed in wells GMD-04 and GMD-05. This is especially applicable for well GMD-05 as this well is upgradient of the mine (both vertically and laterally), and the water in this well has higher chloride concentrations than any of the mine waters.

These wells are also hydraulically separated from shallow groundwater that may have been impacted in the past from mine water discharges to the land surface via a ditch or from a pipe by more than 600 ft of Mancos Shale that has a hydraulic conductivity of approximately 5×10^{-8} cm/sec, a value lower than compacted clay liners used in landfills.

Other geologic units used as potential groundwater resources such as the Menefee Formation and Point Lookout Sandstone do not exist in the Project Area because they have been eroded. The nearest wells that are screened in these two formations are more than four miles to the northeast which is downgradient of the Project Area, due to the regional dip of the geologic units. The potentiometric surface of the Morrison Formation is estimated to be more than 1,200 ft below a well screened in the Menefee Formation. Given this large vertical separation and the fact that there is a downward gradient, water quality in the Morrison Formation or the Dakota Sandstone is not expected to impact these shallower geologic units.

The regional dip of the geologic units and the groundwater flow direction within the Dakota Sandstone and the Morrison Formation are towards the northeast. There are no domestic or stock wells completed in these formations to the northeast of the mine. These two formations are not used for groundwater supply northeast of the mine because the depths of these formations increase due to the regional dip, thus making drilling to these units and pumping groundwater uneconomical.

In summary, there is no evidence that the former mine is currently having an impact on groundwater quality—either at the upgradient former domestic wells in the Project Area or elsewhere.

Answer to Question 3

Subaqueous disposal of tailings has been employed at numerous mining operations to limit the formation of acid-rock drainage and the subsequent leaching of metals. This is because of the slow rate of diffusion of oxygen through water. A water cover is used primarily to halt pyrite oxidation and subsequent acid-rock drainage in the near surface. Molecular oxygen is the primary driver for oxidation reactions involving pyrite (FeS_2). Similarly, limiting oxygen to U(IV) bearing minerals such as coffinite ($USiO_4$) and uraninite [UO_2(cr) or UO_2(a)] will also hinder their dissolution. Upon the cessation of dewatering, the Johnny M Mine would behave similarly to a saturated tailings deposit. Limited access of oxygen and the presence of organic matter (mainly humic materials present in the Westwater Canyon Member) would consume any small amounts of residual oxygen and produce a reducing environment (low Eh) that would stabilize and immobilize U and other constituents as mineral solids.

The overall water quality in the underground workings at the Johnny M Mine was monitored prior to and during backfilling with a sand slurry (and subsequent removal and treatment of the slurry water), that started in August of 1977 and was completed prior to cessation of mining activity in 1982. Subsequently, a sample was collected from the North Vent pipe in 1985 and some additional sampling of the groundwater quality in the Morrison Formation that hosts the backfilled underground workings has recently been conducted as part of the baseline water-quality evaluations being conducted for the proposed Roca Honda Project. The tailings slurry water had elevated concentrations of various constituents (i.e., arsenic, nitrate, molybdenum, selenium, vanadium, gross alpha, radium, thorium, U, chloride, sulfate, and TDS). However, the concentrations of these constituents observed in the underground workings were much lower as a result of immobilization under reducing geochemical conditions (the slurry water was initially oxidizing and in some cases mildly acidic), and because the slurry water was pumped from the mine, treated, and discharged. In the most recent sampling event for well 143, a well screened at a depth approximately coincident with the ore zone, all constituents either meet USEPA public drinking water system standards or are similar to background concentrations.

The historical data, coupled with the voluminous amount of data collected by the proposed Roca Honda project, allows for the assessment of probable impacts to surface and groundwater quality from the former Johnny M Mine.

Itasca is of the opinion that additional investigation of groundwater and surface-water quality in the vicinity of the Project Area is not technically warranted, as sufficient information exists to assess the probable impacts to surface and groundwater quality from the former Johnny M Mine, as discussed in this report.

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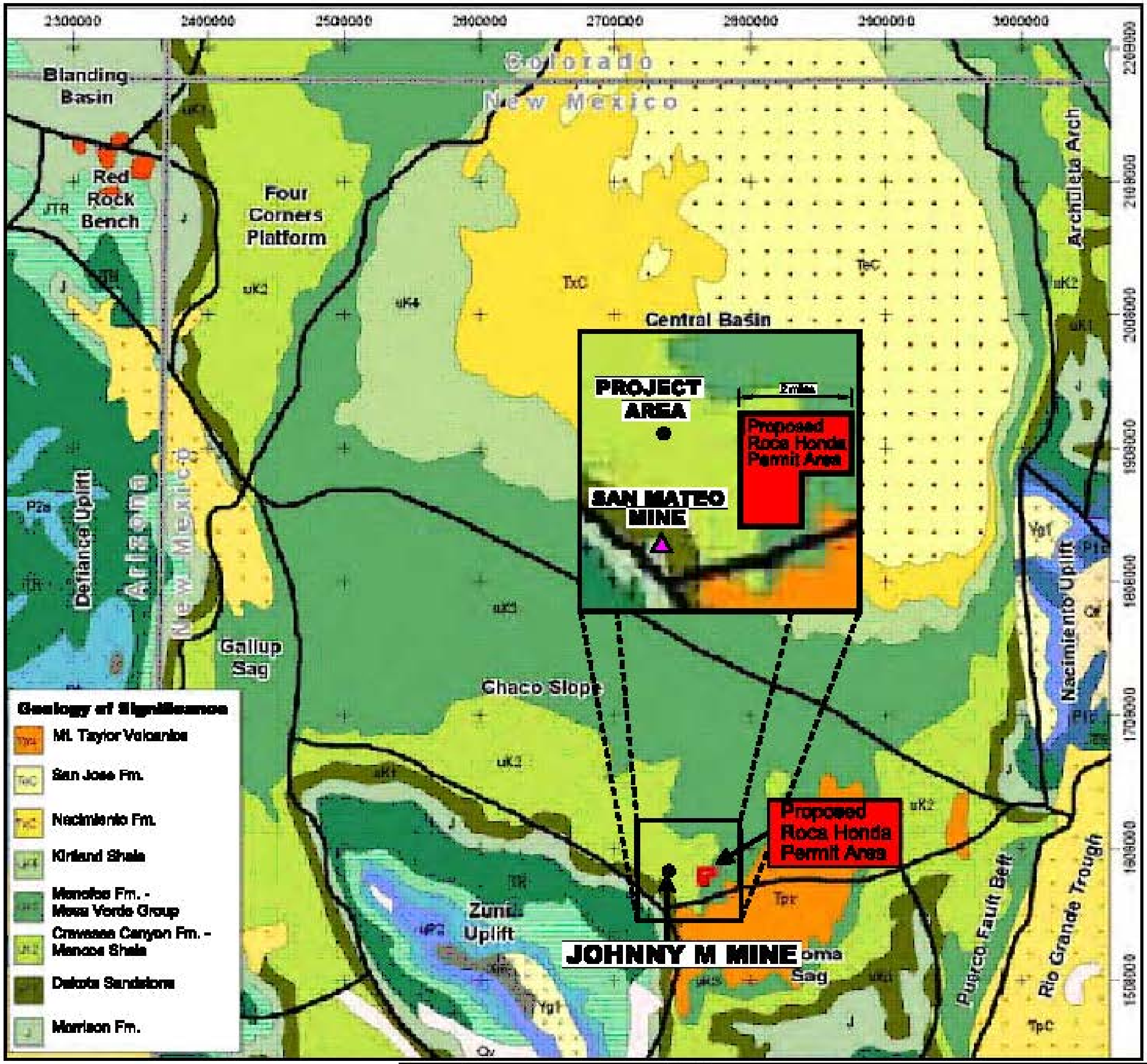

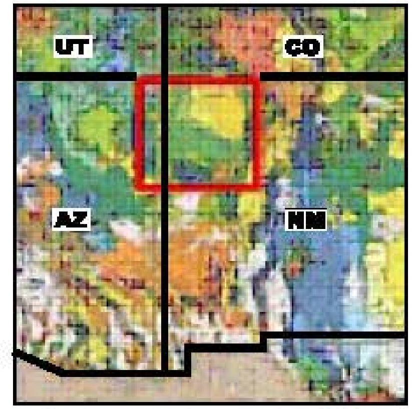

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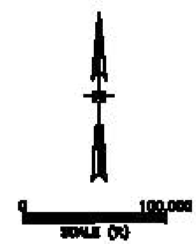

SOURCE: ADAPTED FROM
ROCA HONDA RESOURCES, LLC 2011

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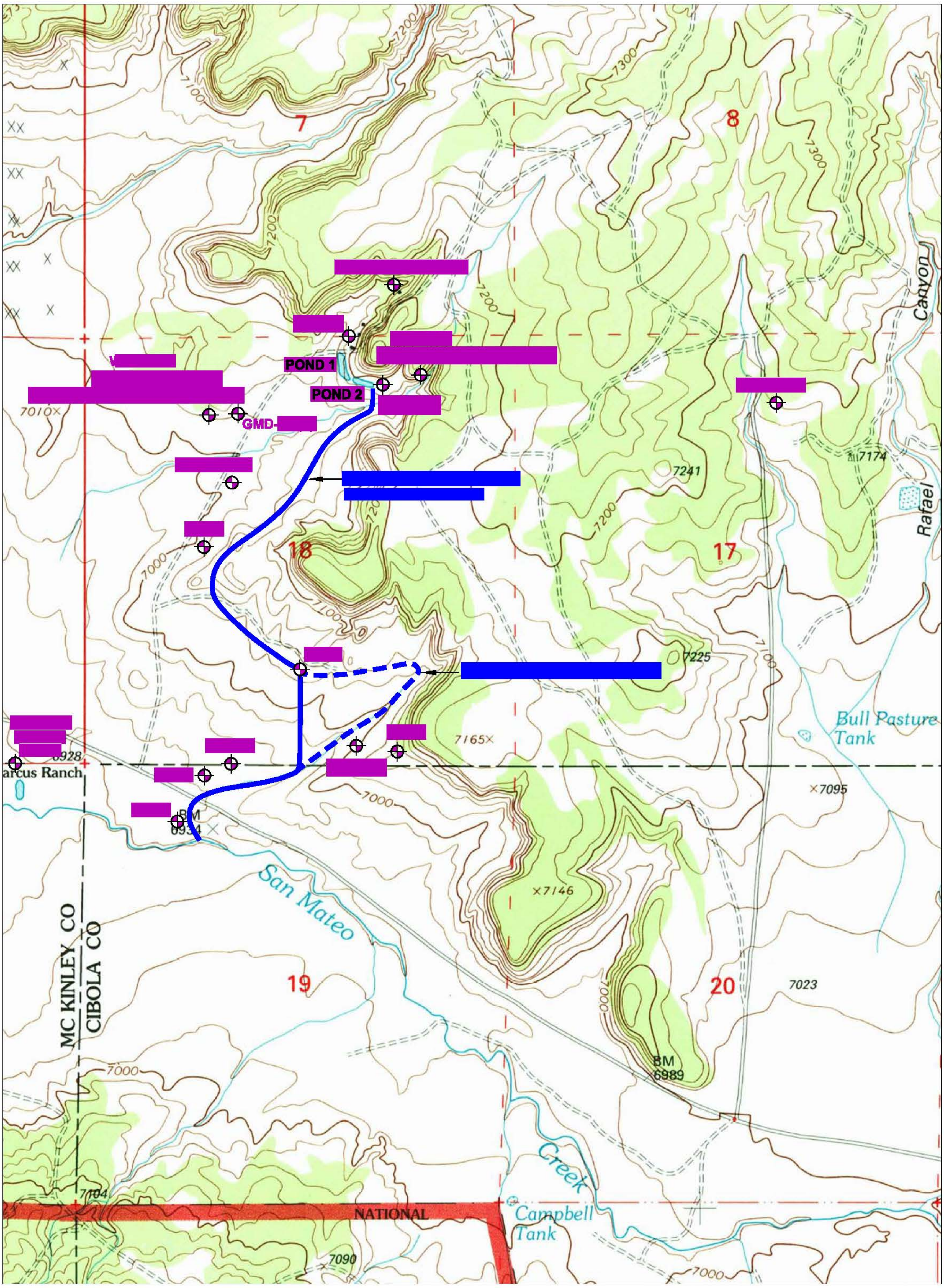
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	REGIONAL-GEOLOGY
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Regional Geology Map of Northwestern New Mexico

CLIENT: Hecla Limited

FIGURE NO. 1



EXPLANATION

WATER-SAMPLING LOCATION

STARTING 3/1/78 EXISTING DRAINAGE CANAL REPLACED WITH 12-in DISCHARGE PIPE

0 — 1/4
SCALE (mile)

NOTE: LOCATION OF THE UNUSED WELL, GMD-05, AT THE FORMER JACKSON PROPERTY IS UNKNOWN.

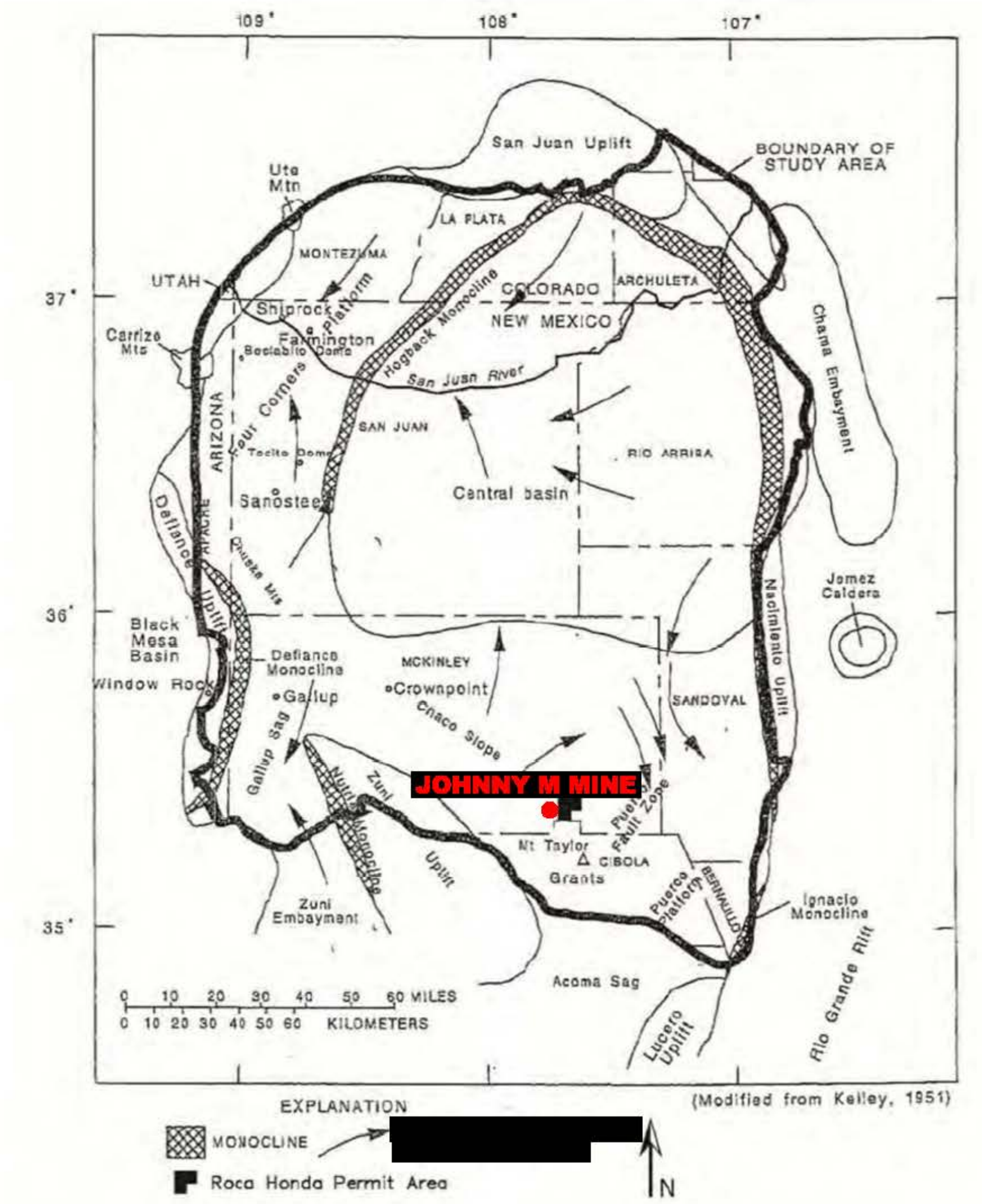
PROJECT NO.	1971
BY	RJS
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	GW-SW-SAMP-LOCS
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Approximate Locations of Groundwater and Surface-Water Sampling Locations

CLIENT: Hecla Limited

FIGURE NO. 2



(Modified from Dam, 1995, Figure 2)

SOURCE: ADAPTED FROM ROCA HONDA RESOURCES, LLC 2011

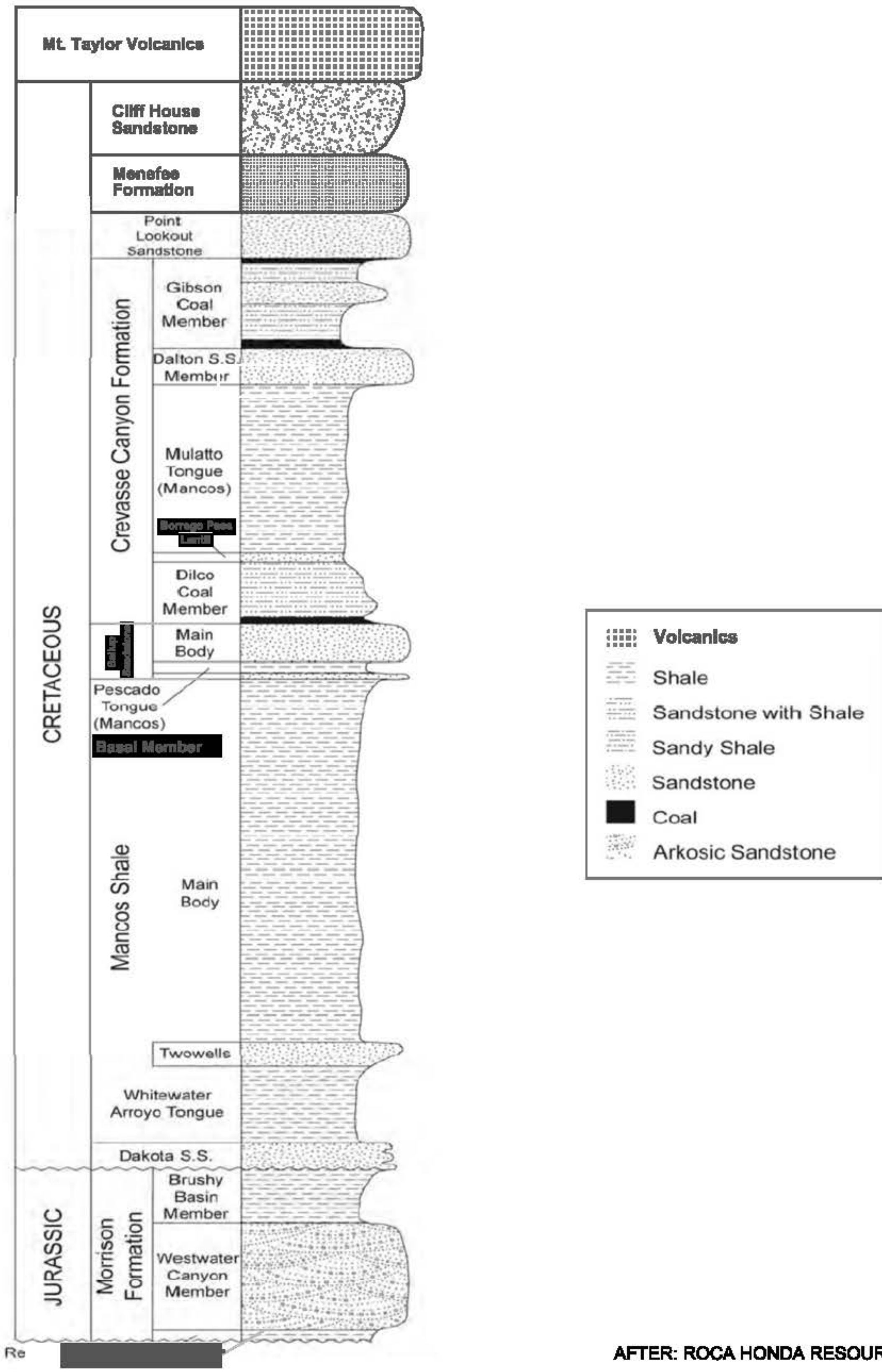
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	STRUCTURE
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Structural Elements of the San Juan Structural Basin and Adjacent Areas and Generalized Patterns of Groundwater Flow in Rocks of Jurassic and Cretaceous Ages

CLIENT: Hecla Limited

FIGURE NO. 3



AFTER: ROCA HONDA RESOURCES, LLC 2011

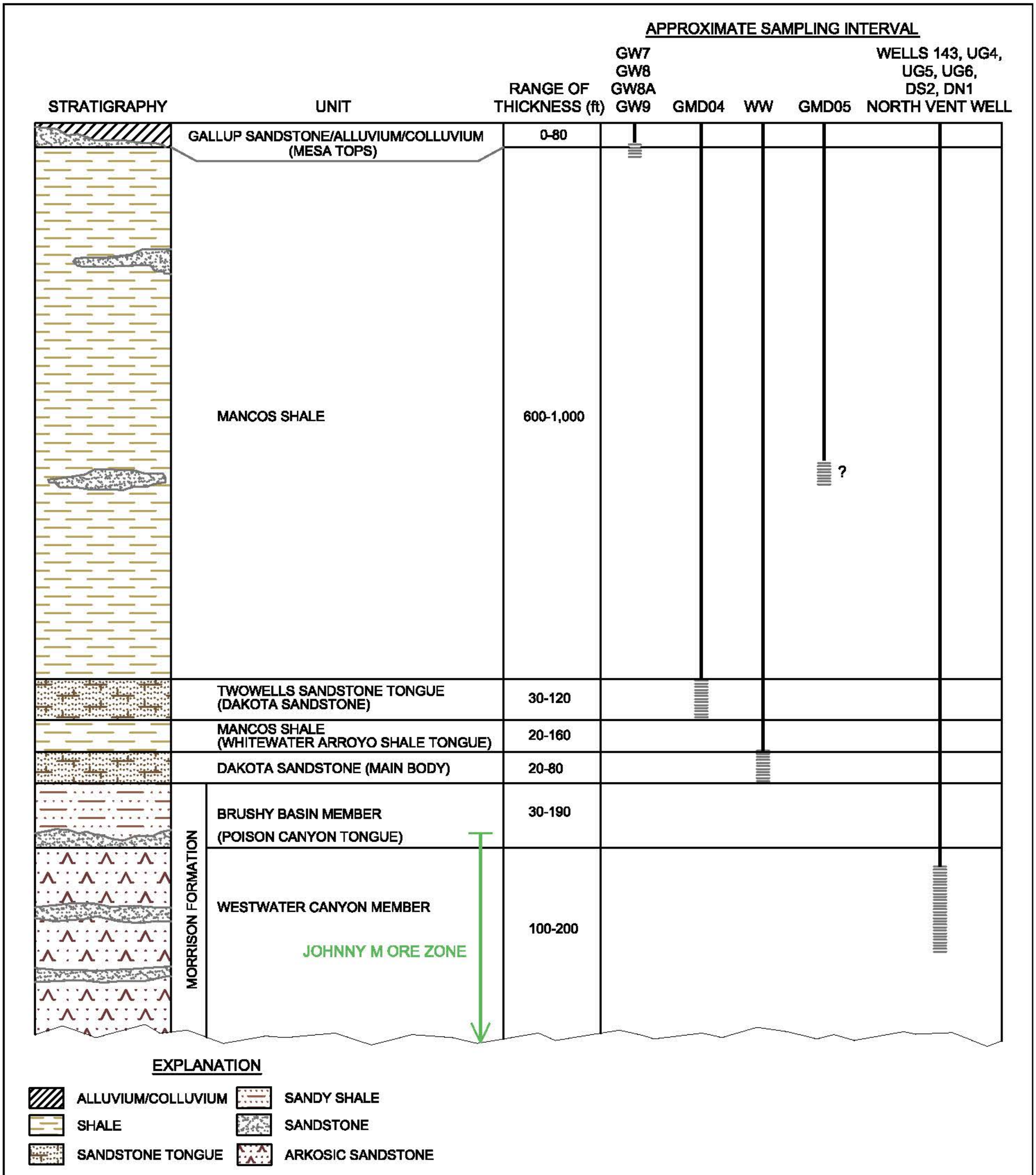
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	STRAT–PERMITAREA
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Typical Regional Stratigraphy within Approximately Five miles of Project Area

CLIENT: Hecla Limited

FIGURE NO. 4



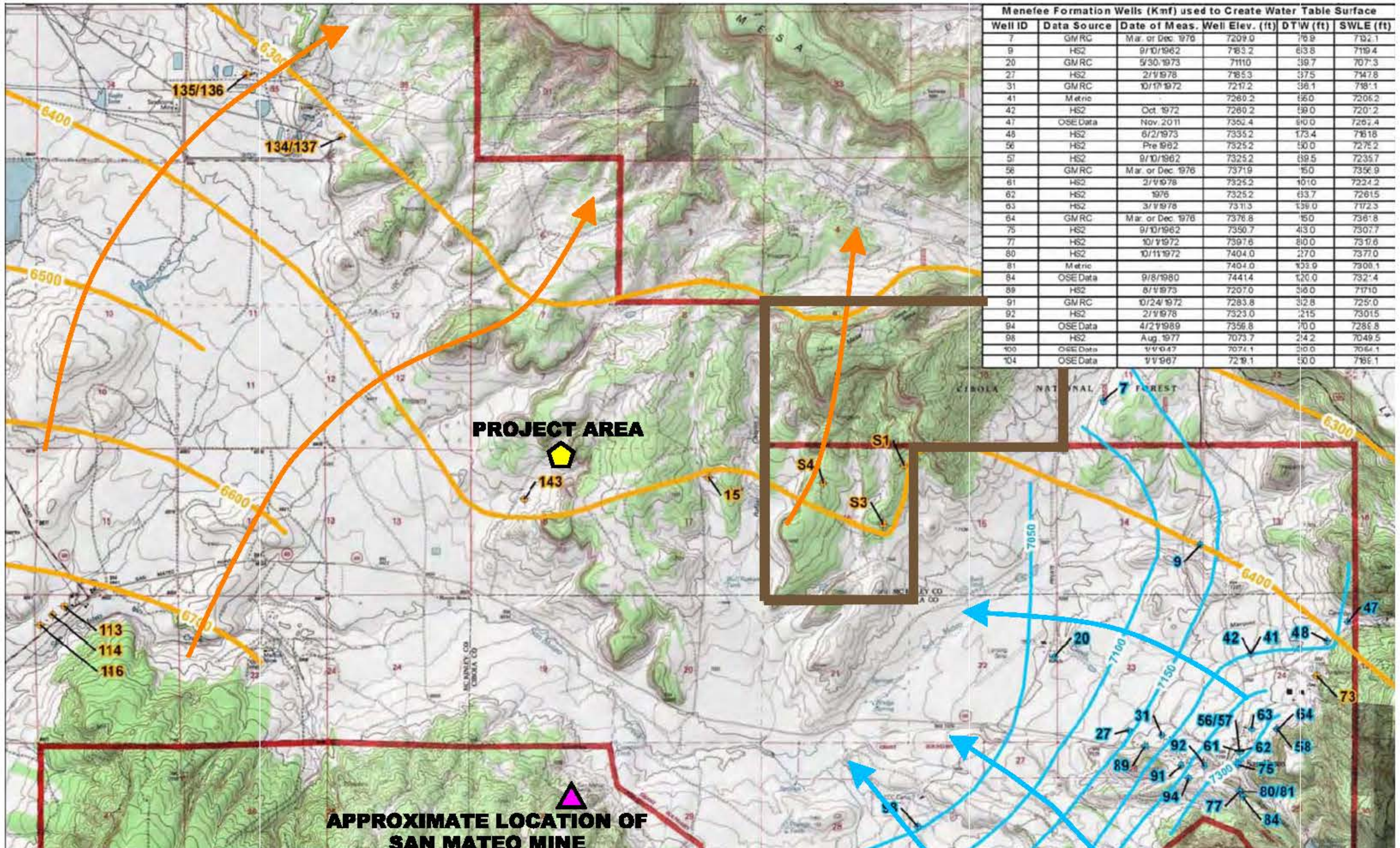
PROJECT NO.	1971
BY	BTH
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	STRAT
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Generalized Stratigraphy of Johnny M Mine Project Area

CLIENT: Hecla Limited

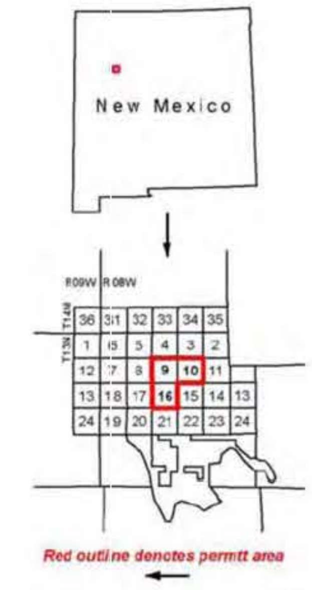
FIGURE NO. 5



Menefee Formation Wells (Kmf) used to Create Water Table Surface					
Well ID	Data Source	Date of Meas.	Well Elev. (ft)	DTW (ft)	SWLE (ft)
7	GMRC	Mar. or Dec. 1976	7209.0	76.9	7132.1
9	HS2	9/10/1962	7183.2	63.8	7119.4
20	GMRC	5/30/1973	7111.0	39.7	7071.3
27	HS2	2/1/1978	7185.3	37.5	7147.8
31	GMRC	10/17/1972	7217.2	36.1	7181.1
41	Metric		7260.2	56.0	7206.2
42	HS2	Oct. 1972	7260.2	59.0	7201.2
47	OSE Data	Nov. 2011	7352.4	90.0	7262.4
48	HS2	6/2/1973	7335.2	173.4	7161.8
56	HS2	Pre 1962	7325.2	50.0	7275.2
57	HS2	9/10/1962	7325.2	89.5	7235.7
58	GMRC	Mar. or Dec. 1976	7371.9	15.0	7356.9
61	HS2	2/1/1978	7325.2	101.0	7224.2
62	HS2	1976	7325.2	63.7	7261.5
63	HS2	3/1/1978	7311.3	139.0	7172.3
64	GMRC	Mar. or Dec. 1976	7376.8	15.0	7361.8
75	HS2	9/10/1962	7350.7	43.0	7307.7
77	HS2	10/1/1972	7397.6	80.0	7317.6
80	HS2	10/11/1972	7404.0	27.0	7377.0
81	Metric		7404.0	103.9	7300.1
84	OSE Data	9/8/1980	7441.4	120.0	7321.4
89	HS2	8/1/1973	7207.0	36.0	7171.0
91	GMRC	10/24/1972	7283.8	32.8	7251.0
92	HS2	2/1/1978	7323.0	21.5	7301.5
94	OSE Data	4/21/1989	7358.8	70.0	7288.8
98	HS2	Aug. 1977	7073.7	24.2	7049.5
100	OSE Data	1/1/1947	7074.1	10.0	7064.1
104	OSE Data	1/1/1967	7219.1	50.0	7169.1

Westwater Canyon Wells (Jmw) used to Create Potentiometric Surface					
Well ID	Data Source	Date of Meas.	Well Elev. (ft)	DTW (ft)	SWLE (ft)
15	RHR Measured	4/31/2010	7167.0	761.3	6405.7
73	Rio Grande Resources	Fall 2010	7240.0	820.0	6420.0
113	USGS	8/9/2009	6830.0	100.7	6729.3
114	RHR Measured	9/27/2010	6837.0	95.1	6741.9
116	OSE Data	5/10/2005	6824.0	80.0	6744.0
134/137	Intera 2007	2006	7071.0	766.0	6305.0
135/136	Intera 2007	2006	7103.0	773.0	6330.0
143	OSE Data	6/14/2009	7010.0	625.0	6385.0
S1	RHR Measured	10/26/2010	7262.9	866.1	6396.8
S3	RHR Measured	10/26/2010	7222.4	826.5	6395.9
S4	RHR Measured	10/19/2010	7248.7	860.3	6388.4

SOURCE: ROCA HONDA RESOURCES, LLC 2011



State Plane Coordinate System
New Mexico, Western Zone, US Foot
NAD 83

Kmf Data Point (Menefee Formation)

Jmw Data Point (Morrison Formation, Westwater Canyon Member)

Kmf Water Table Contour (Menefee Formation)

Jmw Potentiometric Contour (Morrison Formation, Westwater Canyon Member)

0 0.25 0.5 1 Kilometers

0 0.25 0.5 1 Miles

Groundwater Flow Direction for Menefee Formation

Groundwater Flow Direction for Morrison Formation

Proposed Roca Honda Permit Area

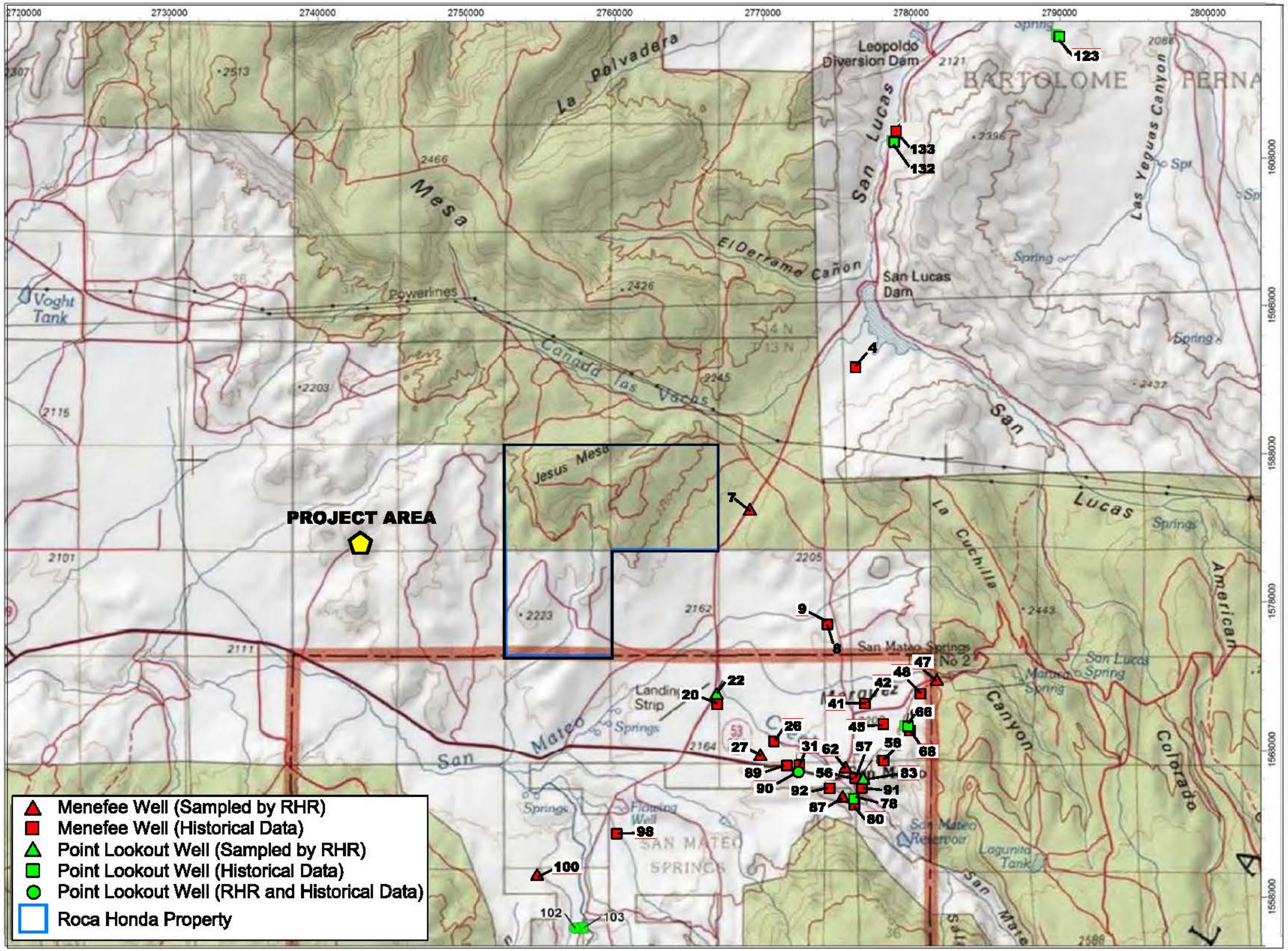
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	MENEFEE–FM
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

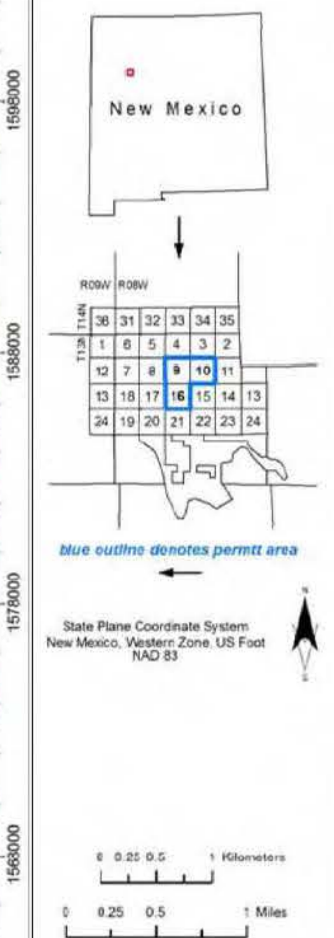
ITASCA™ Denver, Inc.

Modified Water-Table Surface for the Menefee Formation and Potentiometric Surface of Westwater Canyon Member Roca Honda / San Mateo Area

CLIENT: Hecla Limited

FIGURE NO. 6





NOTE:
MENEFEE FORMATION AND
POINT LOOKOUT SANDSTONE
ARE NOT PRESENT IN PROJECT AREA

SOURCE: ROCA HONDA RESOURCES, LLC 2011

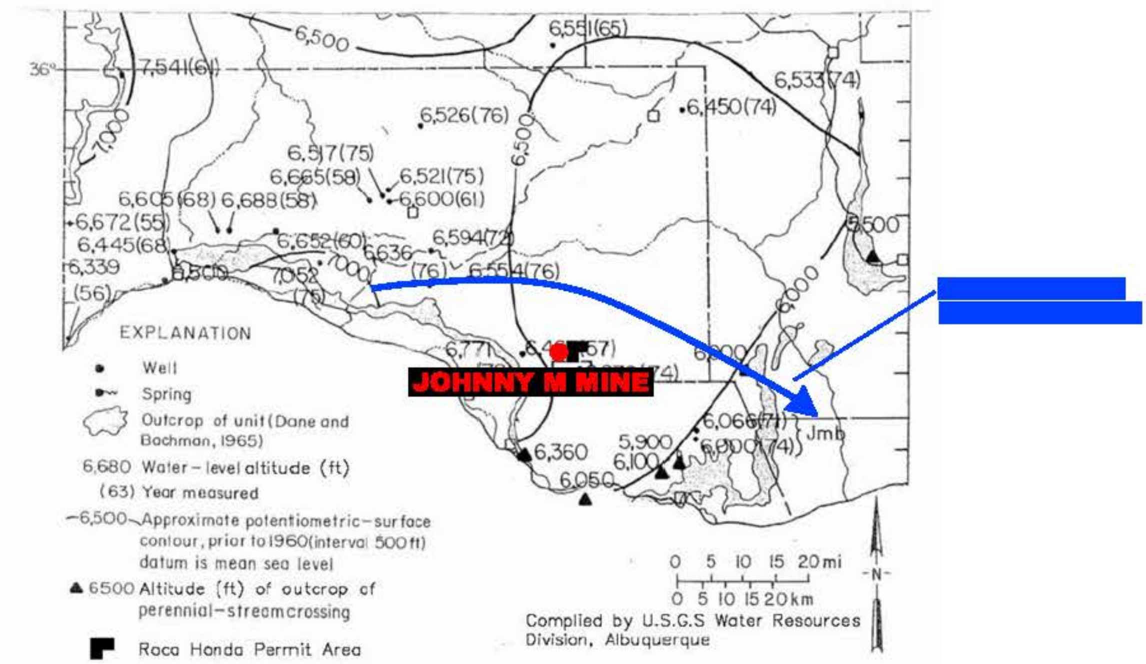
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	WELL-LOCATIONS
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Locations of Menefee and Point Lookout Wells within 10 Miles of Project Area

CLIENT: Hecla Limited

FIGURE NO. 7



Water-Level Elevations and Potentiometric Surface for Westwater Canyon Member
in the Southern Portion of the San Juan Basin
(Modified from Stone et al. 1983, Figure 72)

Simulated Steady State Head in the Westwater Canyon Member
(Modified from Kernodle 1996, Figure 52)

SOURCE: ADAPTED FROM ROCA HONDA RESOURCES, LLC 2011

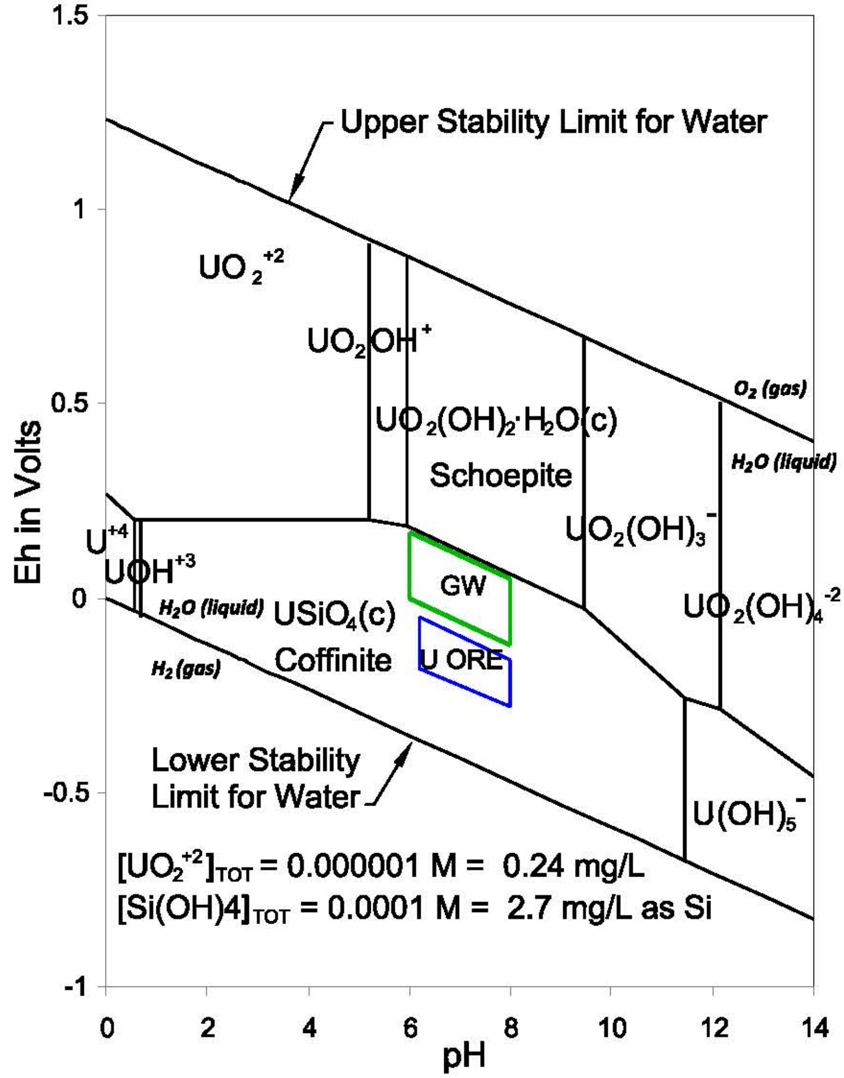
PROJECT NO.	1971
BY	OTHERS/RJS
CHECKED	RJS
DRAWN	OTHERS/SAC
DRAWING NAME	POTENTIOMETRIC
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Potentiometric Surfaces
in Westwater Canyon Member
with Groundwater Flow Directions

CLIENT: Hecla Limited

FIGURE NO. 8



Explanation

GW — Approximate Range of Regional Groundwater Discussed by Thomson et al. (1986)

U ORE — Approximate Range of Groundwater within Ore Zones by Thomson et al. (1986)

Note: The stability field for uraninite occupies a similar but smaller stability range to that illustrated for coffinite

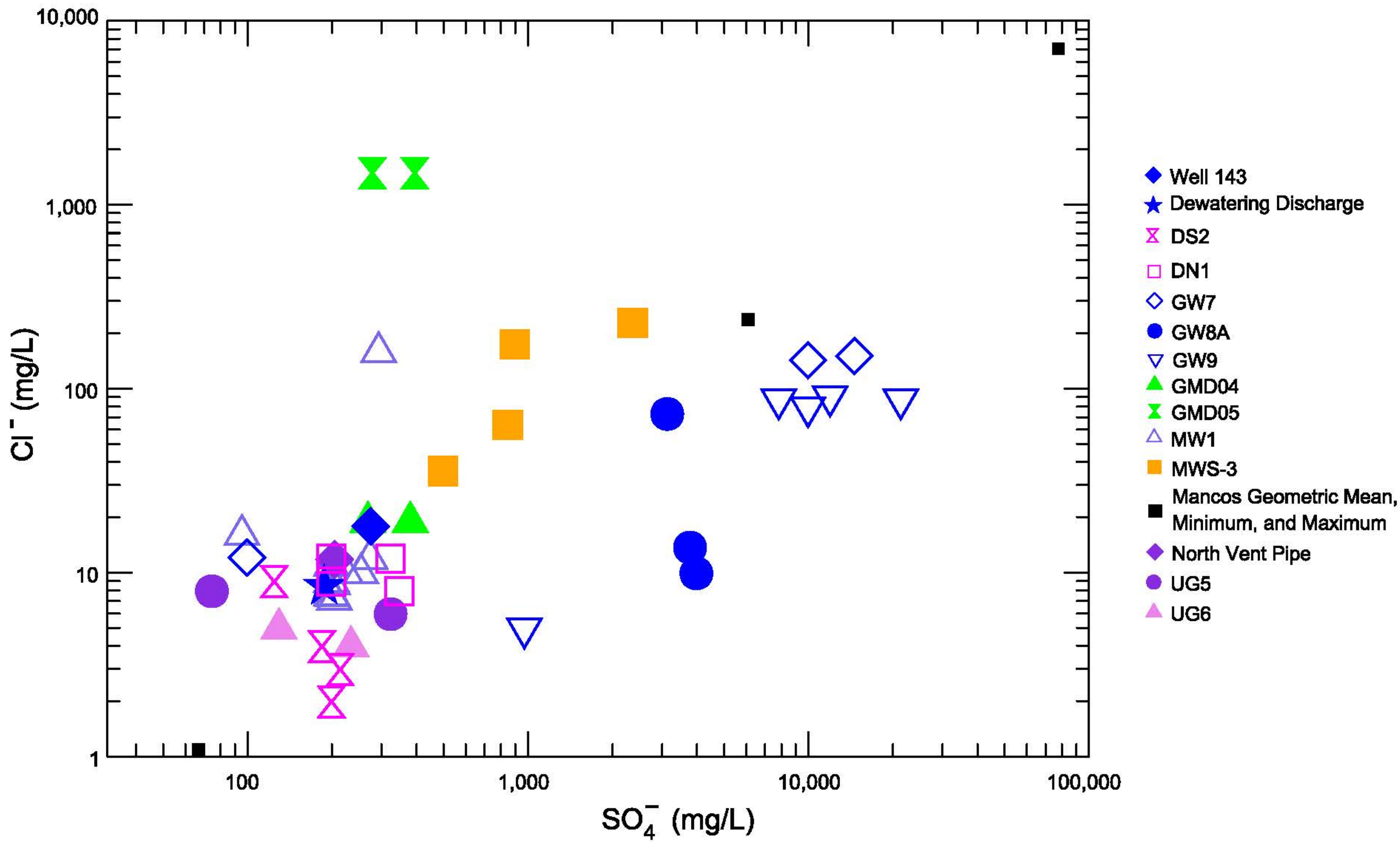
PROJECT NO.	1971
BY	JJM
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	EH-PH
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Eh - pH Diagram for Uranium

CLIENT: Hecla Limited

FIGURE NO. 9



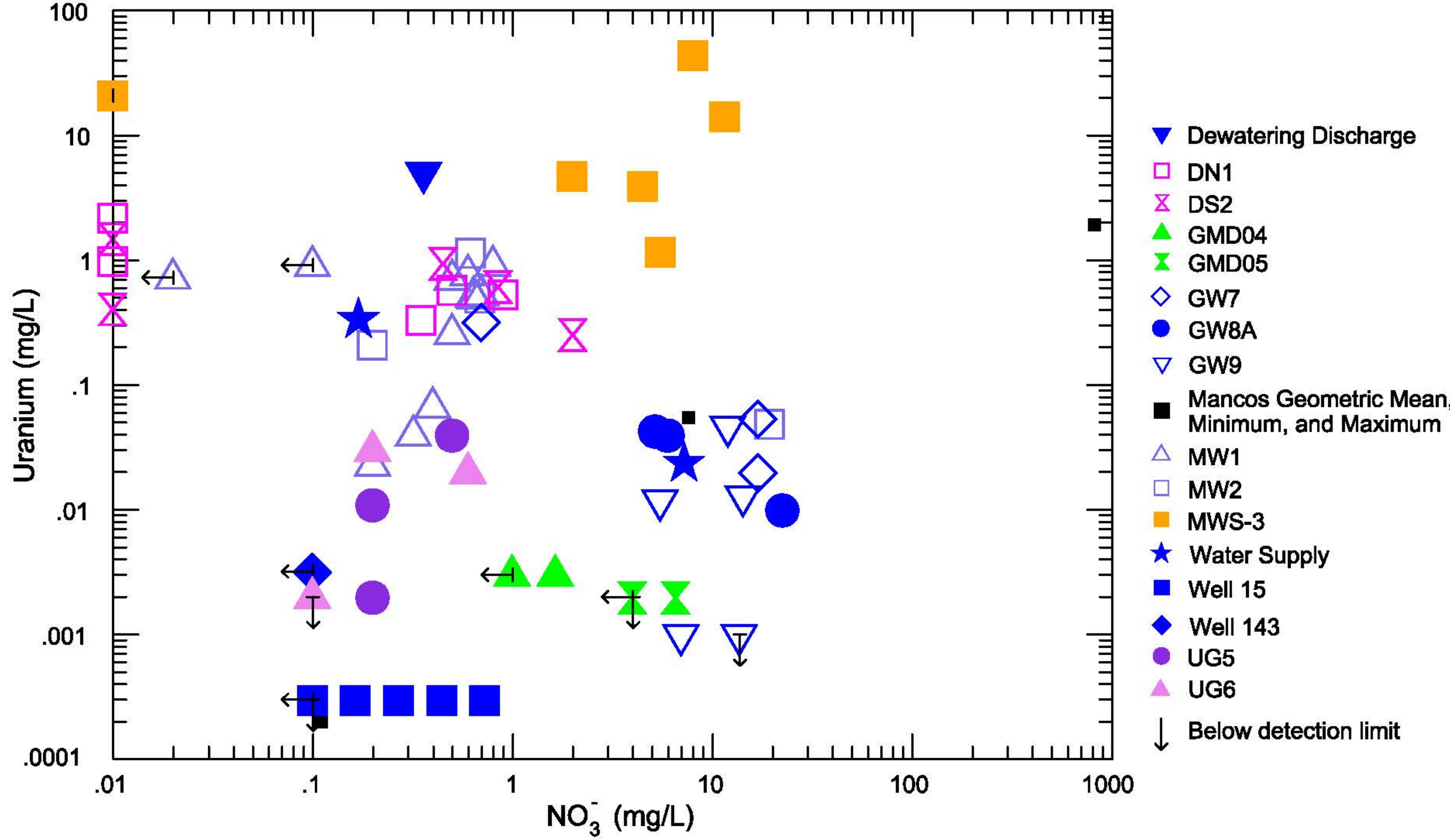
PROJECT NO.	1971
BY	BTH
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	CHLORIDE-SULFATE
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Plot of Chloride and Sulfate Concentrations in Water Samples

CLIENT: Hecla Limited

FIGURE NO. 10



Note:
Some results from historical data reported as "U_3O_8", although the units appear to be mg/L average U. These older data may have comparability issues relative to recent data.

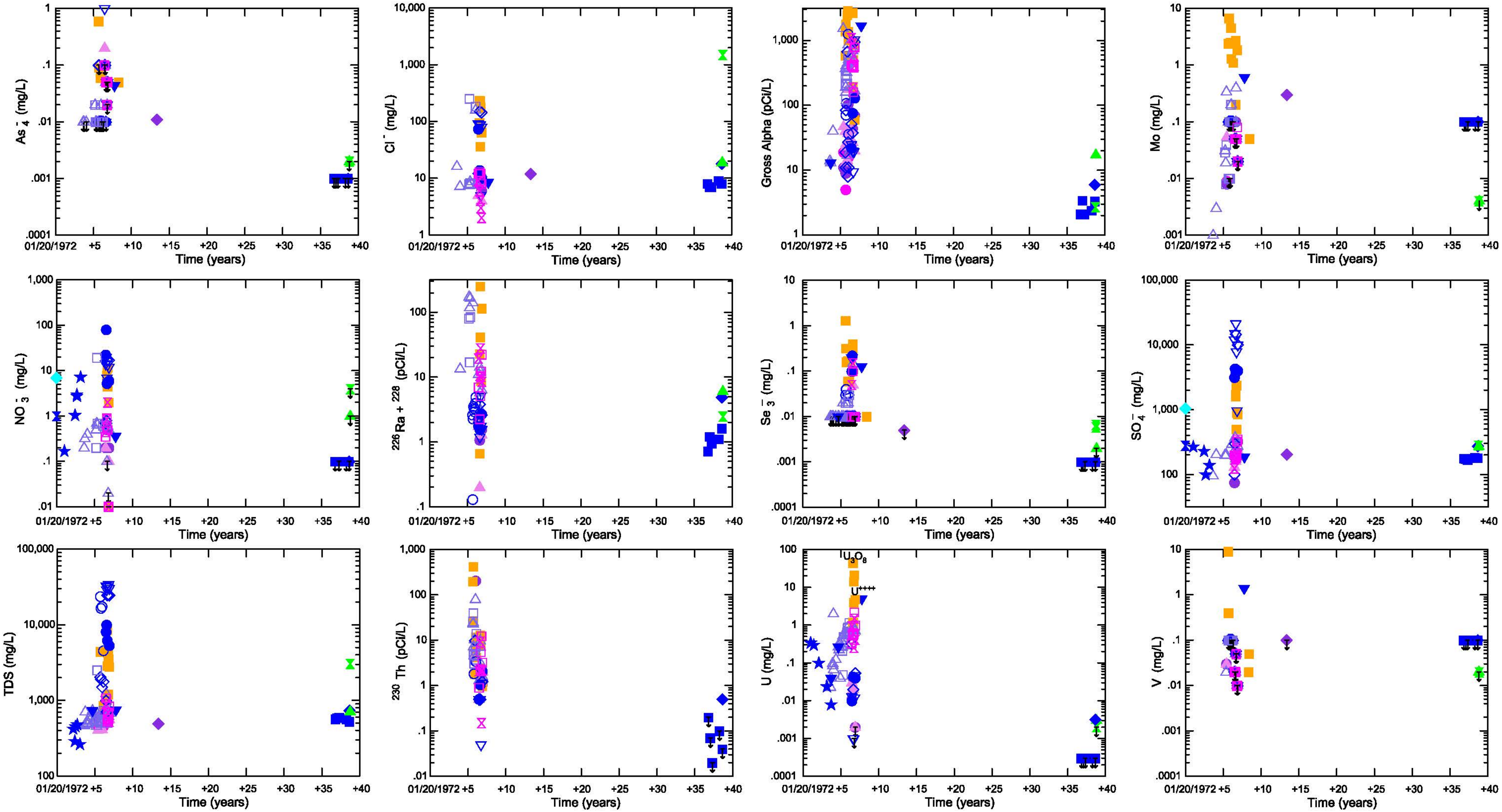
PROJECT NO.	1971
BY	BTH
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	NITRATE–URANIUM
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Plot of Nitrate and Uranium Concentrations in Water Samples

CLIENT: Hecla Limited

FIGURE NO. 11



- ▼ Dewatering Discharge
- □ DN1
- ⧗ DS2
- ▲ GMD04
- ⧗ GMD05
- ◇ GW7
- ○ GW8
- ● GW8A
- ▽ GW9
- △ MW1
- □ MW2
- ■ MWS-3
- ◆ North Vent Pipe
- ● UG4
- ● UG5
- ▲ UG6
- ■ WELL 15
- ◆ WELL 143
- ▼ Weir Water
- ★ Tap Water/Water Supply
- ◆ Dakota Shaft
- ⧗ #30H
- ↓ Below detection limit

Note:
Some results from historical data reported as "U_3O_8", although the units appear to be mg/L average U. These older data may have comparability issues relative to recent data.

PROJECT NO.	1971
BY	BTH
CHECKED	RJS
DRAWN	SAC
DRAWING NAME	VARIOUS-CHEMICALS
DRAWING DATE	11 MAY 2012
REVISION DATE	15 MAR 2013

ITASCA™ Denver, Inc.

Plots of Various Chemical Constituents in Water Samples as a Function of Time

CLIENT: Hecla Limited

FIGURE NO. 12

TABLE 1
Water-Sampling Location Summary

Location ID	Sample Location Type	Formation	Notes
Well 15	Groundwater	Westwater Canyon Member (Morrison Formation)	
Well 143	Groundwater	Westwater Canyon Member (Morrison Formation)	
#30H	?	?	Not used in analysis; data from Johnny M Mine records; location unknown
Dakota Shaft	Groundwater	Dakota Sandstone	
Discharged Water	Mine Water - Discharged	Not Applicable	Mine dewatering samples, collection point unknown
DN-1	Mine Water	Westwater Canyon Member (Morrison Formation)	Mine drainage ditch on north side of shaft prior to intersection of main underground sump
DS-2	Mine Water	Westwater Canyon Member (Morrison Formation)	Mine drainage ditch on south side of shaft prior to intersection of main underground sump
GMD-00	?	?	Not used in analysis; data from NMED/EPA Grants Mining District sampling; location unknown
GMD-01	?	?	Not used in analysis; data from NMED/EPA Grants Mining District sampling; location unknown
GMD-02	?	?	Not used in analysis; data from NMED/EPA Grants Mining District sampling; location unknown
GMD-03	?	?	Not used in analysis; data from NMED/EPA Grants Mining District sampling; location unknown
GMD-04 (Well 17)	Groundwater	Twowells Sandstone Tongue (Dakota Sandstone Interbed within Mancos Shale)	Former domestic well in Project Area; recently used as residential well
GMD-05	Groundwater	Sandstone Lens within Mancos Shale ?	Former domestic well in Project Area; recently unused
GW-7	Groundwater	Alluvium/Mancos Shale Contact	Monitoring well near mine discharge canal
GW-8	Groundwater	Alluvium/Mancos Shale Contact	Monitoring well near mine discharge canal
GW-8A	Groundwater	Alluvium/Mancos Shale Contact	Monitoring well near mine discharge canal
GW-9	Groundwater	Alluvium/Mancos Shale Contact	Monitoring well south of Tailings Pond #2
Mancos Geometric Mean	Groundwater	Mancos Shale	Data from Environmental Sciences Laboratory, 2011
Mancos Maximum	Groundwater	Mancos Shale	Data from Environmental Sciences Laboratory, 2011
Mancos Minimum	Groundwater	Mancos Shale	Data from Environmental Sciences Laboratory, 2011
Marcus Ranch Well	Groundwater	Alluvium	Data from Science Applications International Corporation, 1994
MW-1	Surface Water	Not Applicable	Sampling location at discharge of second of two settling ponds
MW-2	Surface Water	Not Applicable	Sampling location at discharge of drainage canal prior to entry to San Mateo Creek
MWS-3	Tailings Slurry Decant	Not Applicable	Water used to slurry backfill sands into mine
North Vent Pipe	Groundwater	Westwater Canyon Member (Morrison Formation)	Pipe inserted in the north vent pipe shaft to sample backfilled mine water
Tap Water	Groundwater	Dakota Sandstone	Water from Johnny M Mine potable well, collected at the tap
UG-4	Mine Water	Westwater Canyon Member (Morrison Formation)	Sampling location midway between north and south ore bodies
UG-5	Mine Water	Westwater Canyon Member (Morrison Formation)	Sampling location in northrern ore body
UG-6	Mine Water	Westwater Canyon Member (Morrison Formation)	Sampling location in southern ore body
Water Supply (WW)	Groundwater	Dakota Sandstone	Water from Johnny M Mine potable well, collection point unknown
Weir Water	Mine Water - Discharged	Not Applicable	Mine dewatering samples at discharge weir

TABLE 2
Water-Quality Results Compilation
(page 1 of 3)

Location ID	Sample Date	Arsenic	Selenium	TDS	Molybdenum	Vanadium	Radium 226	Radium 228	Radium (226 & 228)	Thorium 230	Lead 210	Lead	Gross Alpha	Zinc	Uranium	Uranium-234	Uranium-235	Uranium-238	Calcium	Magnesium	Potassium	Sodium	Chloride	pH	Sulfate	Alkalinity	U3O8	Nitrate (NO_3 as N)
		mg/l	mg/l	mg/l	mg/l	mg/l	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/l	pCi/L	mg/l	mg/l	pCi/L	pCi/L	pCi/L	mg/l	mg/l	mg/l	mg/l	mg/l	log[H]	mg/l		mg/l	mg/l
15	11/13/2008	< 0.001	< 0.001	567	< 0.1	< 0.1	0.25 +or- 0.13	0.47 +or- 0.73		< 0.2 +or- 0.10		< 0.05	2.1 +or- 1.6	0.1	< 0.0003				51	15	4	143	8	7.9	177	326		< 0.1
15	2/12/2009	< 0.001	< 0.001	588	< 0.1	< 0.1	0.43 +or- 0.18	0.78 +or- 0.73		< 0.07 +or- 0.08		< 0.05	3.4 +or- 1.6	0.15	< 0.0003				46	13	3	127	7	7.52	176	318		0.1
15	5/18/2009	< 0.001	< 0.001	591	< 0.1	< 0.1	<0.1 +or- 0.11	0.85 +or- 0.8		< 0.02 +or- 0.10		< 0.05	2.1 +or- 2	0.08	< 0.0003				48	14	4	136	7	7.81	169	331		< 0.1
15	4/28/2010	< 0.001	< 0.001	568	< 0.1	< 0.1	0.5 +or- 0.17	0.61 +or- 0.72		< 0.1 +or- 0.10		< 0.05	2.4 +or- 2.3	0.08	< 0.0003				47	13	4	135	9	7.63	181	347		< 0.1
15	9/20/2010	< 0.001	< 0.001	523	< 0.1	< 0.1	0.32 +or- 0.15	1.3 +or- 0.59		< 0.04 +or- 0.10		< 0.05	3.3 +or- 3.3	0.09	< 0.0003				45	12	4	139	8	7.85	180	356		< 0.1
143	9/23/2010	< nd	< nd	737	< nd	< nd	3.2	1.7 +or-		0.5		< nd	6	0.4	0.0032				105	21	4	104	18	7.89	276	295		< nd
#30H	26318																		122	23	6.8	160			280		nil	-1
Dakota Shaft	26318																		5.2	14.7	4.8	600			1050		nil	7
Discharged Water	Unknown		< 0.01	737			65.5 +or- 1.3							0.1	0.266													
DN-1	7/18/1978	< 0.1	< 0.01	1076	< 0.05	< 0.02			7.06 +or- 0.32	0.9 +or- 0.8	7.6 +or- 4.2	< 0.02	416 +or- 21	0.15									12	7.39	200		0.333	0.35
DN-1	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DN-1	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DN-1	9/13/1978	< 0.05	0.1	528	0.05	< 0.02			2.26 +or- 0.09	2.36 +or- 0.61	11.4 +or- 1.9	< 0.02	405 +or- 16	0.28									13	6.5	-		0.535	0.9
DN-1	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	190		-	-
DN-1	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DN-1	10/19/1978	< 0.05	< 0.01	692	< 0.05	< 0.05			5.11 +or- 1.4	5.5 +or- 0.8	3.1 +or- 2	< 0.02	161 +or- 20	< 0.01									9	8.2	200		0.58	0.5
DN-1	11/16/1978	< 0.02	< 0.01	572	0.08	< 0.01			12.38 +or- 5.9	12.4	7.1 +or- 4.5	< 0.02	387 +or- 46	0.6									12	9.01	325		2.2	< 0.01
DN-1	12/21/1978	< 0.05	< 0.01	836	< 0.02	< 0.01			22.4 +or- 7.9	3.24 +or- 1.1	8.3 +or- 5	< 0.02	790 +or- 90	0.01									8	7.97	350		0.99	< 0.01
DS-2	7/18/1978	< 0.1	0.05	900	< 0.05	< 0.02			19.4 +or- 2.48	2.1 +or- 1.9	29.8 +or- 6.4	< 0.02	1092 +or- 95	0.5									9	7.33	125		0.946	0.45
DS-2	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DS-2	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DS-2	9/13/1978	< 0.05	0.15	560	0.05	< 0.02			10.46 +or- 1.3	9.4 +or- 1.2	22.6 +or- 2.4	< 0.02	907 +or- 33	0.23									6	6.42	-		0.618	0.85
DS-2	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	180		-	-
DS-2	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
DS-2	10/19/1978	< 0.05	< 0.01	693	< 0.05	< 0.05			27.98 +or- 25	2.1 +or- 0.2	3.5 +or- 2	< 0.02	190 +or- 25	< 0.01									4	8.12	185		0.255	2.01
DS-2	11/16/1978	< 0.02	< 0.01	560	0.02	< 0.01			10.09 +or- 9.8	0.15	5.3 +or- 4	< 0.02	591 +or- 60	0.21									3	8.45	215		1.5	< 0.01
DS-2	12/21/1978	< 0.05	< 0.01	524	< 0.02	< 0.01			8.5 +or- 0.64	2.16 +or- 0.93	5.8 +or- 6	< 0.02	410 +or- 45	0.01									2	8.77	200		0.41	0.01
GMD-00	11/8/2010	< 0.002	< 0.002		< 0.004	< 0.02						< 0.002		0.0488	< 0.002				3.12	1.04	< 1	13.7						
GMD-00	11/8/2010	< 0.002	< 0.002		< 0.004	< 0.02						< 0.002		0.0484	< 0.002				3.01	0.997	< 1	13.4		7				
GMD-00	11/8/2010						<0.752	<0.962					< 0.768			<0.414	< 0.127	< 0.213										
GMD-01	11/8/2010	0.0028	< 0.002		0.0051	< 0.02						< 0.002		< 0.02	< 0.002				46.6	13.6	4.31	23.8						
GMD-01	11/8/2010	0.0026	< 0.002		0.0047	< 0.02						< 0.002		< 0.02	< 0.002				45.6	13.3	4.32	23.4		7				
GMD-01	11/8/2010						<0.65	<0.979					1.28 +or- 0.767			1.598 +or- 0.552	0.147 +or- 0.168	0.864 +or- 0.387										
GMD-02	11/9/2010	0.0063	0.0294		0.0096	0.0232						< 0.002		< 0.02	0.0293				3.28	0.344	< 1	387						
GMD-02	11/9/2010	0.0066	0.0301		0.0091	0.0229						< 0.002		< 0.02	0.0292				3.27	0.345	< 1	385		8.7				
GMD-03	11/9/2010	0.0064	0.0299		0.0093	0.022						< 0.002		< 0.02	0.029				3.26	0.334	< 1	386						
GMD-03	11/9/2010	0.0063	0.0299		0.0088	0.0216						< 0.002		< 0.02	0.0279				3.17	0.338	< 1	370		8.7				
GMD-04	11/8/2010	< 0.002	< 0.002		< 0.004	< 0.02						< 0.002		0.474	0.003				104	21.3	4.11	104						
GMD-04	11/8/2010	< 0.002	< 0.002		< 0.004	< 0.02						< 0.002		0.432	0.003				100	20.5	3.92	99.8		7.4				
GMD-04	11/8/2010			709			3.33 +or- 1.15	2.67 +or- 0.75					17.3 +or- 4.01			1.255 +or- 0.476	< 0.238	0.877 +or- 0.385					19		270	270		< 1
GMD-05	11/8/2010	< 0.002	0.0058		< 0.004	< 0.02						< 0.002		< 0.02	< 0.002				16.6	4.61	4.54	1080						
GMD-05	11/8/2010	< 0.002	0.0066		< 0.004	< 0.02						< 0.002		< 0.02	< 0.002				17.6	4.89	7.22	1160		7.8				
GMD-05	11/8/2010			3070			1.05 +or- 0.71	1.39 +or- 0.57					< 2.67			<0.248	< 0.272	< 0.278					1500		280	390		< 4
GW-7	7/18/1978	0.1	< 0.01	992	0.05	< 0.02			2.3 +or- 0.8	< 0.5 +or- 0.1	< 1 +or- 0.5	< 0.02	52 +or- 5	0.3									12.2	6.6	100		0.32	0.7
GW-7	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	300		-	-
GW-7	8/14/1978	< 0.1	0.01	708	-	-			-	-	-	< 0.02	-	-									-	-	-		-	0.8
GW-7	9/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-7	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-7	9/20/1978	< 0.01	0.01	24740	< 0.05	< 0.05			3.81 +or- 0.78	< 0.5 +or- 0.1	< 1 +or- 0.5	0.4	38 +or- 2	0.02									152	6.56	14634		0.02	17
GW-7	10/19/1978	-	-	-	-	-			-	-	-		-	-									-	-	-		-	-
GW-7	11/16/1978	-	-	-	-	-			-	-	-		-	-									-	-	-		-	-
GW-7	12/21/1978	< 0.05	< 0.01	24592	< 0.02	< 0.01			2.62 +or- 5.2	1.23 +or- 0.8	7 +or- 5	0.04	960 +or- 100	0.14									144	7	10000		0.054	17
GW-7	9/30/1977	< 0.1	< 0.01	-	< 0.1	< 0.1	1.21 +or- 0.2			- -	8.2 +or- 6.6		19 +or- 8	-	-				-	-	-	-	-	-	-	-		-
GW-7	10/14/1977	< 0.1	0.01	2030	< 0.1	< 0.1	0.47 +or- 12			- -	50 +or- 11		11 +or- 4	-	-				-	-	-	-	-	-	-	-		-
GW-7	10/24/1977	< 0.1	< 0.01	-	< 0.1	< 0.1	0.81 +or- 0.2			- -	- -		85 +or- 33	-	-				-	-	-	-	-	-	-	-		-
GW-7	11/14/1977	< 0.01	< 0.01	1910	< 0.1	< 0.1	2.04 +or- 0.48			- -	- -		0 +or- 5	-	-				-	-	-	-	-	-	-	-		-
GW-7	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	0.72 +or- 0.3			- -	- -		0 +or- 5	-	-				-	-	-	-	-	-	-	-		-
GW-7	1/6/1978	< 0.01	< 0.01	1506	< 0.1	< 0.1	138 +or- 6			9.83 +or- 3.06	15 +or- 9		678 +or- 121	-	-				-	-	-	-	-	-	-	-		-
GW-7	1/25/1978	< 0.01	0.01	-	< 0.1	< 0.1	3.85 +or- 0.45			- -	- -		8 +or- 6	-	-				-	-	-	-	-	-	-	-		-
GW-7	2/8/1978	< 0.01	0.03	-	< 0.1	< 0.1	1.23 +or- 0.31			- -	6 +or- 2		27 +or- 7	-	-				-	-	-	-	-	-	-	-		-
GW-7	3/9/1978	< 0.01	0.01	1770	< 0.1	< 0.1	1.68 +or- 0.28			- -	- -		11 +or- 5	-	-				-	-	-	-	-	-	-	-		-
GW-7	4/3/1978	< 0.01	0.01	-	< 0.1	< 0.1	- -			- -	- -		- -	-	-				-	-	-	-	-	-	-	-		-
GW-7	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	- -			- -	- -		- -	-	-				-	-	-	-	-	-	-	-		-
GW-8	9/30/1977	< 0.01	0.03	-	< 0.1	< 0.1			2.61 +or- 0.31	-	10 +or- 6		0 +or- 2.5															
GW-8	10/14/1977	< 0.01	0.04	23722	< 0.1	< 0.1			0.13 +or- 0.09	-	-		0 +or- 4															
GW-8	10/24/1977	< 0.01	0.04	-	< 0.1	< 0.1			2.27 +or- 0.36	-	-		71 +or- 34															
GW-8	11/14/1977	< 0.01	< 0.01	16600	< 0.1	< 0.1			3.53 +or- 0.54	1.83 +or- 0.89	-		108 +or- 30															
GW-8	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1			3.33 +or- 0.49	-	-		0 +or- 26															
GW-8	1/6/1978	< 0.01	< 0.01	17500	< 0.1	< 0.1			2.93 +or- 0.43	-	-		0 +or- 29															
GW-8	1/25/1978	< 0.01	< 0.01	-	< 0.1	< 0.1			3.19 +or- 0.42	-	-		0 +or- 5															
GW-8	2/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1			3.97 +or- 0.55	3.41 +or- 1.57	7 +or- 2		1260 +or- 365															
GW-8	3/9/1978	< 0.01	< 0.01	4560	< 0.1	< 0.1			4.93 +or- 0.64	-	-		36 +or- 36															
GW-8	4/3/1978	< 0.01	< 0.01	-	< 0.1	< 0.1			-	-	-		-															
GW-8	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1			-	-	-		-															
GW-8A	7/18/1978	< 0.1	0.1	8080	< 0.05	< 0.02			1.75 +or- 0.6	< 0.5 +or- 0.1	< 1 +or- 0.5	0.02	22 +or- 3	0.5									73.6	8.54	3150		0.01	22.5
GW-8A	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	4300		-	-
GW-8A	8/14/1978	< 0.1	0.22	9968	-	-			-	-	-	0.35	-	-									-	-	-		-	80
GW-8A	9/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-8A	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-8A	9/20/1978	< 0.01	0.01	6212	< 0.05	< 0.05			1.56 +or- 0.54	1.05 +or- 0.5	< 1 +or- 0.5	0.05	76 +or- 2	0.14									13.8	8.05	3800		0.043	5.2
GW-8A	10/19/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-8A	11/16/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-8A	12/21/1978	< 0.05	< 0.01	5310	< 0.02	< 0.01			2.69 +or- 5.3	2.07 +or- 0.9	2.7 +or- 5	0.06	130 +or- 20	< 0.01									10	7.69	4000		0.04	6

Note: Water-quality data presented here are compiled from available analytical results from Johnny M Mine records provided by Hecla Mining Co. Highlighted values are questionable due to the illegibility of the original from which they were taken.

TABLE 2
Water-Quality Results Compilation
(page 2 of 3)

Location ID	Sample Date	Arsenic	Selenium	TDS	Molybdenum	Vanadium	Radium 226	Radium 228	Radium (226 & 228)	Thorium 230	Lead 210	Lead	Gross Alpha	Zinc	Uranium	Uranium-234	Uranium-235	Uranium-238	Calcium	Magnesium	Potassium	Sodium	Chloride	pH	Sulfate	Alkalinity	U3O8	Nitrate (NO_3 as N)
		mg/l	mg/l	mg/l	mg/l	mg/l	pCi/L	pCi/L	pCi/L	pCi/L	pCi/L	mg/l	pCi/L	mg/l	mg/l	pCi/L	pCi/L	pCi/L	mg/l	mg/l	mg/l	mg/l	mg/l	log[H]	mg/l		mg/l	mg/l
GW-9	7/18/1978	1	0.2	33088	< 0.05	< 0.02			1.81 +or- 0.6	< 0.5 +or- 0.1	< 1 +or- 0.5	0.25	25 +or- 4	2.6									91.4	4.66	12000		0.013	14.3
GW-9	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	15000		-	-
GW-9	8/14/1978	0.1	0.2	29280	-	-			-	-	-	21.5	-	-									-	-	-		-	20
GW-9	9/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-9	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
GW-9	9/20/1978	< 0.01	0.01	31880	< 0.05	< 0.05			1.2 +or- 0.53	< 0.5 +or- 0.1	< 1 +or- 0.5	0.45	20 +or- 1	2.1									88	5.22	21425		0.001	7
GW-9	10/19/1978	< 0.05	< 0.01	32032	< 0.05	< 0.05			5.05 +or- 0.89	< 0.05 +or- 0.01	< 1 +or- 0.5	0.2	9.5 +or- 5	1.2									88	4.83	7869		< 0.001	13.7
GW-9	11/16/1978	< 0.02	< 0.01	34252	< 0.02	< 0.01			1.77 +or- 0.75	0	< 1 +or- 0.5	0.5	19.4 +or- 10	1.86									5	4.24	975		0.012	5.5
GW-9	12/21/1978	< 0.05	< 0.01	30432	< 0.02	< 0.01			1.58 +or- 6.1	1.13 +or- 0.7	4.3 +or- 5.5	0.72	1040 +or- 101	1.6									80	4.75	10000		0.047	12
Mancos Geometric Mean		0.0011	0.0827			0.0006									0.0553	24.3		11.9	336	392	14.3	1692	238	7.4	6114			7.6
Mancos Minimum		0.0002	0.0001			0.0002									0.0002	0.2	0	0.1	48	6.2	0.9	9.3	1.1	4.2	67	0		0.1
Mancos Maximum		0.0229	7.557			0.0190									1.922	489	15	280	600	7000	71.5	25000	7098	8.5	78003	1726		816
Marcus Ranch Well	7/1/1993	< 0.005	< 0.01		< 0.02	< 0.01	0.2 +or- 0.28					< 0.01	6 +or- 15		0.0035									7.6				
MW-1	9/15/1975	< 0.01	< 0.01	468	< 0.001		3.85	-				< 0.001	14 +or- 7	0.517	0.023								16.2		96			0.2
MW-1	10/20/1975	< 0.01	< 0.01	709			2.92	-				< 0.001	13 +or- 9	-	0.04								-		-			0.32
MW-1	12/29/1975	-	< 0.01	491		-	10.3	-				-		-	0.0978								-		-			
MW-1	1/15/1976	-	< 0.01	536			93.2	-				-		-	0.085								-		-			
MW-1	2/2/1976	-	< 0.01				17.5	-				-		-	2.005								-		-			
MW-1	2/11/1976	< 0.01	< 0.01	511	0.003		13.5	0				< 0.001	40.5	0.016	0.0672								7.2		205			0.4
MW-1	6/2/1976	-	< 0.01	545			40.9	-				-		-	0.125								-		-			
MW-1	9/29/1976	-	< 0.01	737			65.5	-				-		-	0.266								-		-			
MW-1	11/3/1976	-	< 0.01	541			70.7	-				-		-	0.227								-		-			
MW-1	12/13/1976	-	-				102	-				-		-	0.33								-		-			
MW-1	1/4/1977	-	-				6.8	-				-		-	0.0403								-		-			
MW-1	2/7/1977	-	-				7.1	-				-		-	0.395								-		-			
MW-1	3/16/1977	-	< 0.01	571			65.5	-				-		-	0.278								-		-			
MW-1	4/15/1977	0.02	< 0.01	460	0.031		172	<1				< 0.001		< 0.01	0.26								7.6		200			0.5
MW-1	5/16/1977	< 0.01	0.02	503	0.019		117	<1				< 0.001		0.007	0.531								7.5		202			0.7
MW-1	6/15/1977	< 0.01	0.01	515	0.34	0.02	165	1				< 0.001	1540 +or- 40	< 0.01	0.516								8.7		202			0.64
MW-1	9/30/1977	0.01	0.01		< 0.1	< 0.1	97.4 +or- 2.4	-		23.2 +or- 2.6	96 +or- 10	-	370 +or- 30	-	-								-		-			
MW-1	10/14/1977	0.01	0.02	504	< 0.1	< 0.1	141 +or- 3	1		24.5 +or- 0.1	< 3.3	-	192 +or- 14	-	-								-		-			
MW-1	10/24/1977	0.01	0.01		0.1	< 0.1	135 +or- 4	-		7.26 +or- 2.64		-	161 +or- 23	-	-								-		-			
MW-1	11/14/1977	0.01	0.01	528	< 0.1	< 0.1	182 +or- 4	-		4.56 +or- 1.24	0 +or- 2	-	417 +or- 33	-	0.58								-		-			
MW-1	12/7/1977	0.01	0.01		< 0.1	< 0.1	30.4 +or- 1.8	-		10.3 +or- 2.3	14 +or- 6	-	321 +or- 34	-	0.85								-		-			
MW-1	1/6/1978	0.01	0.01	526	< 0.1	< 0.1	2.13 +or- 0.32	-		-	7.2 +or- 5.1	-	17 +or- 11	-	0.287								-		-			
MW-1	1/25/1978	0.02	0.02		0.2	0.1	90.6 +or- 3.9	-		79.5 +or- 4.9		-	410 +or- 67	-	0.65								-		-			
MW-1	2/8/1978	0.01	-		0.2	< 0.1	-	-		4.29 +or- 1.58	0 +or- 2	-	861 +or- 102	-	-								-		-			
MW-1	3/9/1978	-	-	700	0.1	< 0.1	-	-		3.49 +or- 2.42	8 +or- 2	-	515 +or- 80	0.01	-								160		295			
MW-1	4/3/1978	-	-		0.1	< 0.1	-	-				-		-	-								-		-			
MW-1	5/8/1978	-	-		0.1	< 0.1	-	-				-		-	-								-		-			
MW-1	7/18/1978	< 0.1	< 0.01	1236	< 0.05	< 0.02			11.1 +or- 2.4	1.3 +or- 1.9	9.7 +or- 5.1	< 0.02	618 +or- 32	0.3									9	7.33	200		0.502	0.65
MW-1	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	375		-	-
MW-1	8/14/1978	< 0.1	< 0.01	488	-	-			-	-	-	< 0.02	-	-									-	-	-		-	0.7
MW-1	9/13/1978	< 0.05	0.15	524	0.1	< 0.02			14.33 +or- 1.02	9.76 +or- 1.1	12.6 +or- 2.1	< 0.02	485 +or- 17	0.04									11	6.58	-		0.915	0.8
MW-1	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	175		-	-
MW-1	9/20/1978	< 0.01	< 0.01	632	0.4	< 0.05			5.77 +or- 2.05	7.1 +or- 1	9.8 +or- 5	0.08	706 +or- 11	0.06									10	7.1	255		0.91	< 0.1
MW-1	10/19/1978	< 0.05	< 0.01	808	< 0.05	< 0.05			12.27 +or- 2.5	3 +or- 0.2	5.2 +or- 3	< 0.02	759 +or- 65	< 0.01									11	8.25	200		0.775	0.6
MW-1	11/16/1978	< 0.02	< 0.01	616	0.02	< 0.01			3 +or- 6	0	4.7 +or- 3	< 0.02	155 +or- 20	0.18									10	9.2	225		0.725	< 0.02
MW-1	12/21/1978	< 0.05	< 0.01	684	< 0.02	< 0.01			6.36 +or- 8.6	1.62 +or- 0.8	5 +or- 6	< 0.02	170 +or- 10	< 0.01									12	8.54	275		0.71	0.5
MW-2	4/15/1977	0.02	< 0.01	548	0.029	-	79.4	<1			-	< 0.001	-	< 0.01	0.211								7.9	8.3				0.2
MW-2	5/16/1977	< 0.01	< 0.01	2520	0.008	-	9.9	7.2			-	< 0.001	-	0.026	0.049								252	8.09				19.4
MW-2	6/15/1977	< 0.01	0.01	522	0.039	-	84	1			-	< 0.001	-	0.01	0.502								8.3	8.14				0.69
MW-2	9/30/1977	0.01	0.02	-	< 0.01	< 0.1	115 +or- 3	-		25.8 +or- 0.5	12 +or- 7	-	300 +or- 30	-	-								-	-				-
MW-2	10/14/1977	0.01	0.02	511	< 0.01	< 0.1	120 +or- 5	-		39.9 +or- 0.1	0 +or- 2	-	211 +or- 14	-	-								-	-				-
MW-2	10/29/1977	< 0.01	0.01	-	0.1	< 0.1	66.7 +or- 3.1	-		4.82 +or- 1.82	-	-	123 +or- 20	-	-								-	-				-
MW-2	11/15/1977	0.01	0.01	505	< 0.01	< 0.1	156 +or- 4	-		3.1 +or- 1.76	16 +or- 6	-	354 +or- 30	-	0.65								-	-				-
MW-2	12/7/1977	0.01	0.01	-	< 0.01	< 0.1	27.9 +or- 1.5	-		3.05 +or- 1.25	0 +or- 2	-	265 +or- 31	-	0.825								-	-				-
MW-2	1/6/1978	0.02	0.01	536	< 0.1	< 0.1	7.49 +or- 0.57	-		0 +or- 0.2	0 +or- 2	-	221 +or- 51	-	0.891								-	-				-
MW-2	1/25/1978	0.02	0.02	680	0.2	< 0.1	16.2 +or- 1.1	-		6.02 +or- 1.91	-	-	385 +or- 64	-	-								-	-				-
MW-2	2/8/1978	0.01	0.01	-	0.1	< 0.1	110 +or- 3	-		7.21 +or- 2.77	8.8 +or- 54	-	583 +or- 59	-	0.695								-	-				-
MW-2	3/9/1978	0.01	0.03	732	0.1	< 0.1	51 +or- 2	-		14 +or- 4.3	7 +or- 1	< 0.05	471 +or- 63	0.01	1.15								185	8.35				0.62
MW-2	4/3/1978	0.01	0.01	-	0.1	< 0.1	-	-		-	-	-	-	-	0.68								-	-				-
MW-2	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-	-		-	-	-	-	-	-								-	-				-
MWS-3	9/30/1977	0.59	1.3	-	2.4	9	177 +or- 3			197 +or- 6	160 +or- 13		1380 +or- 60															
MWS-3	10/14/1977	0.09	0.32	4410	0.1	0.4	24.5 +or- 1			26.7 +or- 0.5	0 +or- 2		589 +or- 84															
MWS-3	10/24/1977	0.01	0.16	-	6.7	< 0.1	640 +or- 9			417 +or- 16	-		1807 +or- 163															
MWS-3	1/6/1978	0.06	0.17	-	2.5	< 0.1	192 +or- 7			1.8 +or- 1.58	50 +or- 15		2484 +or- 173															
MWS-3	1/25/1978	< 0.01	0.06	-	4.5	< 0.1	132 +or- 4			6.72 +or- 0.9	-		2894 +or- 199															
MWS-3	2/8/1978	< 0.01	< 0.01	-	1.3	< 0.1	242 +or- 4			11.8 +or- 3.8	36 +or- 2		1383 +or- 141															
MWS-3	3/9/1978	< 0.01	0.06	856	0.1	< 0.1	19.9 +or- 1.5			4.19 +or- 2.37	10 +or- 1		1014 +or- 114															
MWS-3	5/8/1978	< 0.01	0.16	-	1.1	< 0.1	-			-	-		-															
MWS-3	7/18/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	9/13/1978	< 0.05	0.3	2876	2.7	< 0.02			22.9 +or- 2.48	13 +or- 2.4	36.4 +or- 7.8	< 0.02	2686 +or- 90	0.32									94.4	6.25	-		44.2	8
MWS-3	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	1600		-	-
MWS-3	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	10/19/1978	< 0.05	< 0.01	4288	< 0.05	< 0.05			252.1 +or- 6	12 +or- 1	27.3 +or- 7	< 0.02	929 +or- 90	< 0.01									230	7.55	2375		14.25	11.6
MWS-3	11/16/1978	< 0.02	< 0.01	3536	1.84	< 0.01			8.68 +or- 6.5	0	21.8 +or- 8	< 0.02	862 +or- 80	0.92									176	7.8	900		21	< 0.01
MWS-3	12/21/1978	< 0.05	< 0.01	2792	< 0.02	< 0.01			115 +or- 19	0.99 +or- 0.7	15.8 +or- 7	< 0.02	60 +or- 80	0.05									64	7.83	850		4.8	2
MWS-3	7/18/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	9/13/1978	< 0.05	0.4	8548	0.2	< 0.02			0.66 +or- 0.08	2.46 +or- 0.71	13.2 +or- 4	< 0.02	194 +or- 10	0.64									232	5.4	-		1.175	5.5
MWS-3	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	1700		-	-
MWS-3	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	10/19/1978		< 0.01	1200	< 0.05	< 0.05			41.36 +or- 3.6	7.7 +or- 0.5	17 +or- 5	< 0.02	503 +or- 60	< 0.01									36	8.22	500		3.95	4.5
MWS-3	11/16/1978		-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
MWS-3	12/21/1978		< 0.01	-	-	-			-	-	-	-	-	-									-	-	-		-	-

Note: Water-quality data presented here are compiled from available analytical results from Johnny M Mine records provided by Hecla Mining Co. Highlighted values are questionable due to the illegibility of the original from which they were taken.

TABLE 2
Water-Quality Results Compilation
(page 3 of 3)

ITASCA™ Denver, Inc.

Location ID	Sample Date	Arsenic mg/l	Selenium mg/l	TDS mg/l	Molybdenum mg/l	Vanadium mg/l	Radium 226 pCi/L	Radium 228 pCi/L	Radium (226 & 228) pCi/L	Thorium 230 pCi/L	Lead 210 pCi/L	Lead mg/l	Gross Alpha pCi/L	Zinc mg/l	Uranium mg/l	Uranium-234 pCi/L	Uranium-235 pCi/L	Uranium-238 pCi/L	Calcium mg/l	Magnesium mg/l	Potassium mg/l	Sodium mg/l	Chloride mg/l	pH log[H]	Sulfate mg/l	Alkalinity	U3O8 mg/l	Nitrate (NO_3 as N) mg/l
North Vent Pipe	6/19/1985	0.011	< 0.005	495	0.3	< 0.1						< 0.1		< 0.1					6.3 or 48	15 or 24.9			11.9		205			
Tap Water	Unknown			480															35	11.4				7.72	100			2.77
Tap Water	27687						2.34 +or- 0.23						0 +or- 2		0.008													
UG-4	7/5/1977	< 0.01	< 0.01	452	0.009	0.03	2.7 +or- 0.03			-	-		19 +or- 5															
UG-4	9/30/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	2.7 +or- 0.29			-	-		11 +or- 7															
UG-4	10/14/1977	< 0.01	< 0.01	469	< 0.1	< 0.1	3.29 +or- 0.35			-	-		5 +or- 3															
UG-4	10/29/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	2.09 +or- 0.28			-	-		9 +or- 6															
UG-4	11/15/1977	< 0.01	< 0.01	468	< 0.1	< 0.1	3.16 +or- 0.41			-	-		10 +or- 5															
UG-4	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	0.49 +or- 0.29			-	-		0 +or- 5															
UG-4	1/6/1978	< 0.01	< 0.01	430	< 0.1	< 0.1	0 +or- 0.05			-	-		0 +or- 5															
UG-4	2/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	2.92 +or- 0.47			-	-		18 +or- 3															
UG-4	3/9/1978	< 0.01	< 0.01	454	< 0.1	< 0.1	1.49 +or- 0.4			-	-		16 +or- 5															
UG-4	4/3/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-4	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-4	1/25/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	5.75 +or- 0.06			-	-		18 +or- 9															
UG-5	7/5/1977	< 0.01	< 0.01	567	0.008	0.03	5.9 +or- 0.6			-	-		11 +or- 5															
UG-5	9/30/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	1.09 +or- 0.22			-	-		11 +or- 7															
UG-5	10/14/1977	< 0.01	< 0.01	609	< 0.1	< 0.1	0.68 +or- 0.17			-	-		9 +or- 5															
UG-5	10/29/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	1.79 +or- 0.35			-	-		9 +or- 6															
UG-5	11/15/1977	< 0.01	< 0.01	640	< 0.1	< 0.1	4.94 +or- 0.49			-	9.7 +or- 7.7		11 +or- 4															
UG-5	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	1.01 +or- 0.22			-	0 +or- 2		0 +or- 5															
UG-5	1/6/1978	< 0.01	< 0.01	570	< 0.1	< 0.1	0.8 +or- 0.18			-	-		0 +or- 5															
UG-5	1/25/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	1.86 +or- 0.28			-	-		0 +or- 5															
UG-5	2/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	2.05 +or- 0.4			204 0.9	6 +or- 2		103 +or- 11															
UG-5	3/9/1978	< 0.01	< 0.01	680	< 0.1	< 0.1	0.79 +or- 0.3			-	-		20 +or- 7															
UG-5	4/3/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-5	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-5	7/18/1978	< 0.1	< 0.01	908	< 0.05	< 0.02			2.1 +or- 0.6	< 0.5 +or- 1	< 1 +or- 0.5	< 0.02	26 +or- 3	0.3									8	7.38	75		0.011	0.2
UG-5	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	9/13/1978	< 0.05	0.1	632	0.1	< 0.02			1.07 +or- 0.09	1.66 +or- 0.4	< 1 +or- 0.5	< 0.02	44 +or- 5	0.22									10.4	6.48	-		0.04	0.5
UG-5	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	175		-	-
UG-5	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	10/19/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	11/16/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-5	12/21/1978	< 0.05	< 0.01	728	< 0.02	< 0.01			1.56 +or- 5.7	1.08 +or- 0.5	< 1 +or- 0.5	< 0.02	70 +or- 10	0.01									6	8.62	325		0.002	0.2
UG-6	7/5/1977	< 0.01	< 0.01	407	0.054	0.03	5.8 +or- 0.6			-	-		47 +or- 8															
UG-6	9/30/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	6.17 +or- 0.48			-	9.9 +or- 6.7		40 +or- 11															
UG-6	10/14/1977	< 0.01	< 0.01	459	< 0.1	< 0.1	6.26 +or- 0.47			-	-		13 +or- 6															
UG-6	10/29/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	7.39 +or- 0.5			-	-		23 +or- 3															
UG-6	11/15/1977	< 0.01	< 0.01	440	< 0.1	< 0.1	10.1 +or- 0.9			-	12 +or- 6		26 +or- 6															
UG-6	12/7/1977	< 0.01	< 0.01	-	< 0.1	< 0.1	0 +or- 0.1			-	12 +or- 6		0 +or- 5															
UG-6	1/6/1978	< 0.01	< 0.01	414	< 0.1	< 0.1	4.69 +or- 0.61			-	-		14 +or- 9															
UG-6	1/25/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	97.8 +or- 4			4.81 +or- 0.39	-		178 +or- 31															
UG-6	2/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	4.17 +or- 0.57			-	5 +or- 2		37 +or- 5															
UG-6	3/9/1978	< 0.01	< 0.01	516	< 0.1	< 0.1	5.36 +or- 0.76			-	-		28 +or- 5															
UG-6	4/3/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-6	5/8/1978	< 0.01	< 0.01	-	< 0.1	< 0.1	-			-	-		-															
UG-6	7/18/1978	0.2	< 0.01	832	< 0.05	< 0.02			1.75 +or- 0.6	< 0.5 +or- 0.1	< 1 +or- 0.5	< 0.02	42 +or- 4	0.2									5	7.26	130		0.03	0.2
UG-6	8/13/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	8/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	9/13/1978	< 0.05	0.05	496	0.05	< 0.02			0.2 +or- 0.07	1.02 +or- 0.32	< 1 +or- 0.5	< 0.02	27 +or- 3	0.02									9.2	6.36	-		0.02	0.6
UG-6	9/14/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	160		-	-
UG-6	9/20/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	10/19/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	11/16/1978	-	-	-	-	-			-	-	-	-	-	-									-	-	-		-	-
UG-6	12/21/1978	< 0.05	< 0.01	560	< 0.02	< 0.01			1.28 +or- 5.5	2.02 +or- 0.8	< 1 +or- 0.5	0.1	20 +or- 1	< 0.01									4	8.54	235		< 0.002	0.1
Water Supply (WW)	Unknown														0.024				40	8					140			7.26
Water Supply (WW)	Unknown			265										< 0.1					38	7.3	5.6	11.8		7.11				
Water Supply (WW)	Unknown			480										0.2					34	11.4				7.65	100			2.99
Water Supply (WW)	Unknown			453										< 0.1					33	11.6	7	55		7.21	230			1.05
Water Supply (WW)	Unknown			290										< 0.1					4	6.9	8.5	60		7.1				
Water Supply (WW)	26846																										0.3	
Water Supply (WW)	27089																										0.1	
Water Supply (WW)	Unknown			423															22	11.1	10.4	63		7.6				
Water Supply (WW)	Unknown																		40	53					270		0.34	0.17
Weir Water	27687						2.92 +or- 0.26						13 +or- 9		0.04													

Note: Water-quality data presented here are compiled from available analytical results from Johnny M Mine records provided by Hecla Mining Co. Highlighted values are questionable due to the illegibility of the original from which they were taken.

Appendix B

Applicable or Relevant and Appropriate Requirements (ARARs)

Appendix B ARARs

Summary of Federal and State Potential Applicable or Relevant and Appropriate Requirements (ARARs) Compliance Johnny M Mine Site

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
Federal								
40 CFR 122	The NPDES program requires permits for the discharge of pollutants from any point source into waters of the United States.	X	X	X			X	The remedial alternative will not result in point source dischargers. Moreover, no federal permit is required for work on the site per 42 U.S.C. §9621(e)(1) and 40 CFR 300.400.
40 CFR 141	These regulations protect the health-based quality of public drinking water supplies through regulation of maximum contaminant levels (MCLs), some of which correspond to COPCs.	X				X		The MCLs for COPCs in mine-related material may be relevant and appropriate depending on the land use and institutional controls at the site. No ground or surface water is currently being impacted by the site COPCs.
40 CFR 50	Implementing regulations to support the Clean Air Act providing primary and secondary ambient air quality standards	X					X	No stationary sources exist or are being constructed within the project area; therefore, this regulation is not applicable or relevant and appropriate.

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
40 CFR 61	Regulations containing the National Emission Standards for Hazardous Air Pollutants (NESHAPs).	X				X		The NESHAP standard for radon-222 emission from uranium mill tailings piles contained in 40 CFR 40.61 of a 20 $pCi/m^{-2}\ s^{-1}$ cover design criteria is not applicable but is relevant and appropriate to the protectiveness of the selected removal action.
40 CFR 192	Implementing regulations of the Uranium Mill Tailing Radiation Control Act. Establishes enforceable standards for cleanup levels of radionuclides for sites affected by uranium mill tailings. Governs stabilization, disposal, and control of uranium and thorium mill tailings by setting health and environmental protection standards.	X				X		The UMTRCA standard of 5 pCi/g above background for radium-226 in soil is not applicable but is relevant and appropriate since the one of the COPCs for the project area is radium-226

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
16 U.S.C § 470f; 36 CFR Part 800; and 36 CFR Parts 63 and 80	National Historic Preservation Act (NHPA) and Implementing regulations of NHPA		X				X	Requires the federal agencies to take into account the consequences of their “undertakings,” on a district, site, building, structure, or object that is included in, or is eligible for, inclusion in the National Register of Historic Places. Regulates the inventory, assessment, and consultation on removal project efforts and protection measures for cultural properties on Federal land. The site is not eligible for inclusion on the National Register, nor does the site contain any such buildings structures or objects. Moreover, no federal permit is required for work on the site per 42 U.S.C. §9621(e)(1) and 40 CFR 300.400. Therefore, these requirements are not applicable or relevant and appropriate.

Appendix B ARARs

Summary of Federal and State Potential Applicable or Relevant and Appropriate Requirements (ARARs) Compliance Johnny M Mine Site

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
16 U.S.C. § 469	Archaeological and Historic Preservation Act of 1974		X			X		Provides for preservation of significant scientific, prehistoric, historic, and archaeological data which may be affected by removal efforts. These requirements are likely not applicable because no archaeological items have been identified within the project area. However, if archaeological items are found during project work, this may be relevant and appropriate.
43 CFR Part 7	Implementing regulations of the Archaeological Resources Protection Act of 1979		X			X		Requires permits for excavation of archaeological resources on public or tribal lands. These requirements are not applicable because the site is not on public or tribal lands and, moreover, no archaeological items have been identified within the project area. However, if archaeological items are found during project work, these requirements may be relevant and appropriate.

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
43 CFR Part 10	Implementing regulations of the Native American Graves Protection and Repatriation Act		X			X		Establishes regulations pertaining to the identification, protection, and appropriate disposition of human remains, funerary objects, sacred objects, or objects of cultural patrimony. Because the Act does not apply to private land, these requirements are not applicable. However, if cultural objects are found during project work, these requirements may be relevant and appropriate.
40 CFR Part 257	Resource Conservation and Recovery Act Subtitle D Regulations, Criteria for Classification of Solid Waste Disposal Facilities and Practices.		X			X		These regulations establish federal criteria for use in siting the disposal of solid waste in certain locations. Although these requirements are not applicable as an exemption applies here, these regulations are relevant and appropriate to the design of the onsite waste repository.

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
33 CFR 330	Implementing regulations of Section 404, Clean Water Act.		X			X		Regulates discharge of dredge or fill materials into waters of the U.S. Permit is not required per 42 U.S.C. § 9621(e)(1) and 40 CFR 300.400. However, substantive requirements of the regulations may be relevant and appropriate to any dredge or fill activities, to the extent waters of the United States are impacted in project area.
16 U.S.C. § 662	Fish and Wildlife Coordination Act (FWCA)		X				X	Requires consultation with Federal and State agencies to provide adequate protection of fish and wildlife resources, specifically when modification of any stream or other water body is proposed. No fish or wildlife resources will be impacted by removal action. Not applicable or relevant and appropriate.

Appendix B ARARs

Summary of Federal and State Potential Applicable or Relevant and Appropriate Requirements (ARARs) Compliance Johnny M Mine Site

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
16 U.S.C. § 1531 et seq.; 50 CFR, Part 402	Endangered Species Act of 1973 (ESA), and ESA implementing regulations		X				X	Regulates the protection of threatened or endangered species and critical habitat. Requires action to conserve endangered plant and animal species within critical habitats upon which they depend. A proposed action may not jeopardize continued existence of endangered species or destroy or adversely modify a critical habitat. No evidence of endangered species or critical habitat within project area. Not applicable or relevant and appropriate.
29 CFR	Implementing regulations of Occupational Safety and Health Act (OSHA)			X	X			Regulates worker health and safety. Applicable.
49 CFR 107, 171-177	Implementing regulations of Hazardous Materials Transportation Act – Standards Applicable to Transport of Hazardous Materials			X	X			Applicable if mine-related material is transported on pubic roadways.
40 CFR Part 192	Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings			X		X		Standards for the control of residual radioactive materials from inactive uranium processing sites. Relevant and appropriate

Appendix B ARARs
Summary of Federal and State Potential Applicable or Relevant and Appropriate Requirements (ARARs) Compliance Johnny M Mine Site

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
10 CFR Part 20	NRC Standards for Protection Against Radiation			X		X		Sets permissible dose levels, radioactivity concentration limits for effluents, precautionary procedures, waste disposal requirements for NRC licensees, and establishes protocols for protection of workers, protection of the public, discharges to air and water, and waste treatment and disposal. No NRC license is needed so not applicable but relevant and appropriate.
40 CFR Part 440	Ore Mining and Dressing Point Source Category address in NPDES			X		X		Radionuclide concentration limits for surface water discharges of radioactive waste. Potentially relevant and appropriate to the extent waters of the united States are impacted in project area.

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
40 CFR 122	Stormwater discharges from construction sites.			X		X		Requires a permit (general or individual) for point source discharges of stormwater from construction activities. Permit is not required per 42 U.S.C. § 9621(e)(1) and 40 CFR 300.400. However, substantive requirements of the regulations may be relevant and appropriate to activities during response action implementation, to the extent waters of the United States are impacted in project area.
State								
20.2.3 NMAC	New Mexico Ambient Air Quality Standards establish standards for air pollutants in order to prevent or improve air quality deterioration.	X				X		This regulation provides the maximum allowable concentrations of total suspended particulate in the ambient air, and is applicable. As no stationary sources exist, these requirements are not applicable. However, they may be relevant and appropriate to dust control efforts during response action implementation.

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
20.6.2 and 20.6.4 NMAC	New Mexico Ground and Surface Water Protection Standards.	X				X		Regulations governing water quality protection in New Mexico. Establishes water quality standards for the state, including description of the designated use(s), the criteria necessary to protect the use(s), and anti-degradation policies. No ground or surface water is currently being impacted by the site COPCs. Moreover, no discharge permit will be required for the selected removal action. However, the New Mexico groundwater protection standards for COPC in mine-related material are relevant and appropriate as they relate to the protectiveness of the selected remedial alternative.
20.3.13.1317 NMAC	New Mexico Protection of the General Population from Release of Radioactivity			X		X		Same as 40 CFR 192. Not applicable but relevant and appropriate.
20.3.4 NMAC	Standards for Protection Against Radiation			X		X		Same as 10 CFR 20. Not applicable but relevant and appropriate.

Regulation	Description	ARAR Type			Potential ARAR Category			Comment
		Chemical	Location	Action	Applicable	Relevant and Appropriate	Not Applicable, Relevant and Appropriate	
19.10.5 NMAC	Performance and Reclamation Standards and Requirements for Non-Coal Mining, Existing Mining Operations.			X		X		This regulation provides re-vegetation requirements for existing, non-coal mining operations as well as other reclamation requirements. Relevant and appropriate.

POTENTIAL ADVISORIES, CRITERIA, POLICY OR GUIDANCE TO BE CONSIDERED		
Item	**Citation**	**Discussion**
Federal		
Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination	EPA OSWER 9200.4-18	Clarifies that cleanups of radionuclides are governed by the risk range for carcinogens established in the 10^{-6} to 10^{-4} range when ARARs are not achievable or not sufficiently protective. To be considered
Regional Soil Screening Levels, Region 6.	http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm	The screening levels (SLs) presented for this site were developed using risk assessment guidance from the EPA Superfund program. They are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. SLs are considered by the Agency to be protective for humans (including sensitive groups) over a lifetime; however, SLs are not always applicable to a particular site. The SLs contained in the SL table are generic; they are calculated without site-specific information. However, they will be considered in developing site-specific screening levels.
US EPA Technical Report on Technologically Enhanced Naturally Occurring Radioactive Materials ("TENORM") from uranium mining	*TENORM Vol. 2: Investigation of Potential Health, Geographic, and Environmental Issues of Abandoned Uranium Mines*. EPA 402-R-05-007 August 2007	Provides non-regulatory soil screening levels for external exposure, incidental ingestion, and inhalation of fugitive dust to certain radionuclides common to uranium mine sites. Also provides guidance on assessing human health and ecological risk at uranium mine sites.
State		
New Mexico Soil and Water Conservation District Act	73-20-25 NMSA	Establishes state authority to control and prevent soil erosion, prevent floodwater and sediment damage to soil, and conserve natural resources. To be considered.

Appendix C

EE/CA Removal Alternatives Cost Estimate

JOHNNY M MINE EECA REMOVAL ALTERNATIVES COST ESTIMATE

OFF-SITE ALTERNATE
ENERGY SOLUTIONS, CLIVE UTAH

Removal to 3.5 pCi/g Residential Use Criterion

11/10/2014

Item #	Description	Material(s)	Units	$/Unit	Quantity	Cost, $	Cost Reference	Quantity Reference
	Direct Reclamation Costs							
1	**Mobilization/ Demobilization - Construction Contractor**	labor, equipment	1	lump sum	1	$ 91,774	NM MMD Financial Assurance Guidebook	(3% of other total on-site direct)
2	**Worker Health and Safety**							
2.1	RSO, full-time	labor	hrs	$ 130	2600	$ 338,000	ERG	full time for 12 months, 50 hrs/wk, 2600 hrs
2.2	Technician	labor	hrs	$ 80	1300	$ 104,000	ERG	half time for 12 months, 50 hrs/wk, 1300 hrs
3	**Radiological Surveying, Sampling and Testing**							
3.1	Mobilization/ Demobilization	labor,equipment	lump sum	$ 2,000	1	$ 2,000	ERG	
3.2	Remediation support surveys	labor,equipment	hrs	$ 80	2600	$ 208,000	ERG	item 4.3
3.3	Field gamma surveying	labor,equipment	lump sum	$ 40,000	1	$ 40,000	ERG	
3.4	Soil sample testing	contract lab	each	$ 130	1380	$ 179,400	ERG	Estimate based on 2000 m^2 SU segments for residential use (assumed), 10000 m^2 for industrial use. Table 4-26 SIR for areas and volumes.
4	**Construction Management**							
4.1	Construction superintendent	labor	wk	$ 2,050	52.0	$ 106,600	RSM 2014 01 31 13.20 0240	full time for 7 months, 50 hrs/wk, 1515 hours
4.2	Field engineer	labor	wk	$ 1,350	52.0	$ 70,200	RSM 2014 01 31 13.20 0120	full time for 7 months, 50 hrs/wk, 1515 hours
4.3	Ground control and volumetrics surveying	labor,equipment	day	$ 802	91	$ 73,183	RSM 2014 01 71 23.13 1100	quarter time
4.4	Field lab operations for soil testing	labor,equipment	wk	$ 1,025	0	$ -	RSM 2014 01 31 13.20 0100	one-third time
4.5	Field QC technicians for soil liner/cover	labor	wk	$ 1,025	0	$ -	RSM 2014 01 31 13.20 0100	one-third time
4.6	QC records and reports clerk	labor	wk	$ 435	52	$ 22,620	RSM 2014 01 31 13.20 0020	
4.7	Field Office - 32' x 8' unit and 20' x 8' unit, furnished; 2 portable toilets	equipment	month	$ 1,171	18	$ 21,078	RSM 2014 01 52 32.20; 01 52 13 40; 01 54 33 40 6410	Office trailer remains on site for 18 months
4.8	Truck and equipment pressure washer	labor,equipment	month	$ 540	12	$ 6,480	RSM 2014 01 54 33 40 5460	
4.9	Dust control	labor,equipment	day	$ 1,625	365	$ 593,125	RSM 2014 31 23.23.20 2510	
5	**Clearing of Vegetation**	labor,equipment	acre	$ 252	111	$ 27,972	RSM 2014 31 13 13.10 0550	
6	**Removal of Contaminated Mine-Related Materials**							
6.1	Excavation of contaminated soil and mine waste rock							
	by scraper, 5000 ft haul	labor,equipment	BCY	$ 5.26	28139	$ 148,011	RSM 2014 31 23 16.50 2440; Caterpillar Performance Handbook	CAT 621;
	by scraper, 3000 ft haul	labor,equipment	BCY	$ 4.31	59276	$ 255,479	RSM 2014 31 23 16.50 2430; Caterpillar Performance Handbook	CAT 621
	by scraper, 1500 ft haul	labor,equipment	BCY	$ 3.32	129835	$ 431,051	RSM 2014 31 23 16.50 2420; Caterpillar Performance Handbook	CAT 621
	by excavator and truck, 0.5 m.i RT	labor,equipment	BCY	$ 4.13	23054	$ 95,211	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4014; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
	by excavator and truck, 1.0 mi. RT	labor,equipment	BCY	$ 4.35	173428	$ 754,411	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4016; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
	by excavator and truck, 2.0 mi. RT	labor,equipment	BCY	$ 4.75	2870	$ 13,631	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4018; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
6.2	Load for off-site haul	labor,equipment	LCY	$ 0.50	499921	$ 249,960	RSM 2014 31 23 16.43 0450; Caterpillar Performance Handbook	CAT 990F with 10 cy bucket; total BCY *1.2
6.3	Transport by rail from Milan, NM siding							
	Haul by truck to Milan siding	labor,equipment	LCY	$ 5.86	499921	$ 2,929,536	RSM 2014 31 23 23.20 4110-4112	20 CY truck, 18 miles site to siding
	Loading into gondola cars	labor,equipment	LCY	$ 0.95	499921	$ 474,925	RSM 2014 31 23 16.42 1601	load from truck to rail car with CAT 980
	Gondola mobilization fee	equipment	each	$ 5,500	100	$ 550,000	MHF Services, email 3/13/14	per 110 T capacity gondola car
	Gondola lease rate	equipment	month	$ 625	900	$ 562,500	MHF Services, email 3/13/14	per 110 T capacity gondola car
	Rail rate to EnergySolutions	equipment	car trip	$ 10,000	5454	$ 54,536,808	MHF Services, email 3/13/14	per 110 T capacity gondola car, 1.2 T/CY
6.4	Transport by truck from mine site							
	Haul by truck and dump - EnergySolutions, Clive, UT	labor,equipment	trip	$ 6,240	26312	$ 164,184,495	MHF Services, email 3/13/14	23 tons or 19 cy/trip
7	**Disposal at Licensed Facility**							
	EnergySolutions	fee	LCY	$ 45	499921	$ 22,496,433	EnergySolutions email 4/1/14	$30/T, est. 1.2 T/cy
8	**Site Restoration**							
	Final grading	labor,equipment	acre	$ 774.40	111	$ 85,958	RSM 2014 31 22 16.10 3300	Grade fo drainage and revegetation
	Revegetation - seeding with mulch and fertilizer	labor,equipment	acre	$ 938.28	111	$ 104,149	RSM 2014 32 92 19.14 5300	Drll seeding with mulch and fertilizer
9	**Post-Removal Site Controls**							
	Annual Inspections and Reports	labor	Yr	$ 1,714.00	12	$ 20,568	RSM 2014 01 13 13.20	one trip per year, scientist and technician for two days
TOTAL DIRECT COST				By Rail		**$ 85,593,063**		
				By Truck		**$ 190,723,790**		

Estimated duration of construction = 12 months 52.0 weeks 365 days, two 6-month work periods separated by 6 months

Waste volume for removal. Based on clean-up to 3.5 pCi/g Ra-226, is 318,502 m^3 or 416,601 CY bank volume; or ~500,000 LCY
Time-based work assumes half the waste volume is removed in each of two consecutive years, six months each year
LCY = BCY x 1.2
1 CY = 1.5 T

JOHNNY M MINE EECA REMOVAL ALTERNATIVES COST ESTIMATE

OFF-SITE ALTERNATE
WASTE CONTROL SPECIALISTS, ANDREWS, TEXAS

Removal to 3.5 pCi/g Residential Use Criterion

11/10/2014

Item #	Description	Material(s)	Units	$/Unit	Quantity	Cost, $	Cost Reference	Quantity Reference
	Direct Reclamation Costs							
1	**Mobilization/ Demobilization - Construction Contractor**	labor,equipment	1	lump sum	1	$ 91,774	NM MMD Financial Assurance Guidebook	(3% of other total on-site direct)
2	**Worker Health and Safety**							
2.1	RSO, full-time	labor	hrs	$ 130	2600	$ 338,000	ERG	full time for 12 months, 50 hrs/wk, 2600 hrs
2.2	Technician	labor	hrs	$ 80	1300	$ 104,000	ERG	half time for 12 months, 50 hrs/wk, 1300 hrs
3	**Radiological Surveying, Sampling and Testing**							
3.1	Mobilization/ Demobilization	labor,equipment	lump sum	$ 2,000	1	$ 2,000	ERG	
3.2	Remediation support surveys	labor,equipment	hrs	$ 80	2600	$ 208,000	ERG	item 4.3
3.3	Field gamma surveying	labor,equipment	lump sum	$ 40,000	1	$ 40,000	ERG	
3.4	Soil sample testing	contract lab	each	$ 130	1380	$ 179,400	ERG	Estimate based on 2000 m^2 SU segments for residential use (assumed), 10000 m^2 for industrial use. Table 4-26 SIR for areas and volumes.
4	**Construction Management**							
4.1	Construction superintendent	labor	wk	$ 2,050	52.0	$ 106,600	RSM 2014 01 31 13.20 0240	full time for 7 months, 50 hrs/wk, 1515 hours
4.2	Field engineer	labor	wk	$ 1,350	52.0	$ 70,200	RSM 2014 01 31 13.20 0120	full time for 7 months, 50 hrs/wk, 1515 hours
4.3	Ground control and volumetrics surveying	labor,equipment	day	$ 802	91	$ 73,183	RSM 2014 01 71 23.13 1100	quarter time
4.4	Field lab operations for soil testing	labor,equipment	wk	$ 1,025	0	$ -	RSM 2014 01 31 13.20 0100	one-third time
4.5	Field QC technicians for soil liner/cover	labor	wk	$ 1,025	0	$ -	RSM 2014 01 31 13.20 0100	one-third time
4.6	QC records and reports clerk	labor	wk	$ 435	52	$ 22,620	RSM 2014 01 31 13.20 0020	
4.7	Field Office - 32' x 8' unit and 20' x 8' unit, furnished; 2 portable toilets	equipment	month	$ 1,171	18	$ 21,078	RSM 2014 01 52 32.20; 01 52 13 40; 01 54 33 40 6410	Office trailer remains on site for 18 months
4.8	Truck and equipment pressure washer	labor,equipment	month	$ 540	12	$ 6,480	RSM 2014 01 54 33 40 5460	
4.9	Dust control	labor,equipment	day	$ 1,625	365	$ 593,125	RSM 2014 31 23.23.20 2510	
5	**Clearing of Vegetation**	labor,equipment	acre	$ 252	111	$ 27,972	RSM 2014 31 13 13.10 0550	
6	**Removal of Contaminated Mine-Related Materials**							
6.1	Excavation of contaminated soil and mine waste rock							
	by scraper, 5000 ft haul	labor,equipment	BCY	$ 5.26	28139	$ 148,011	RSM 2014 31 23 16.50 2440; Caterpillar Performance Handbook	CAT 621;
	by scraper, 3000 ft haul	labor,equipment	BCY	$ 4.31	59276	$ 255,479	RSM 2014 31 23 16.50 2430; Caterpillar Performance Handbook	CAT 621
	by scraper, 1500 ft haul	labor,equipment	BCY	$ 3.32	129835	$ 431,051	RSM 2014 31 23 16.50 2420; Caterpillar Performance Handbook	CAT 621
	by excavator and truck, 0.5 m.i RT	labor,equipment	BCY	$ 4.13	23054	$ 95,211	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4014; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
	by excavator and truck, 1.0 mi. RT	labor,equipment	BCY	$ 4.35	173428	$ 754,411	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4016; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
	by excavator and truck, 2.0 mi. RT	labor,equipment	BCY	$ 4.75	2870	$ 13,631	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4018; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
6.2	Load for off-site haul	labor,equipment	LCY	$ 0.50	499921	$ 249,960	RSM 2014 31 23 16.43 0450; Caterpillar Performance Handbook	CAT 990F with 10 cy bucket; total BCY *1.2
6.3	Transport by rail from Milan, NM siding							
	Haul by truck to Milan siding	labor,equipment	LCY	$ 5.86	499921	$ 2,929,536	RSM 2014 31 23 23.20 4110-4112	20 CY truck, 18 miles site to siding
	Loading into gondola cars	labor,equipment	LCY	$ 0.95	499921	$ 474,925	RSM 2014 31 23 16.42 1601	load from truck to rail car with CAT 980
	Gondola mobilization fee	equipment	each	$ 5,500	100	$ 550,000	MHF Services, email 3/13/14	per 110 T capacity gondola car
	Gondola lease rate	equipment	month	$ 625	900	$ 562,500	MHF Services, email 3/13/14	per 110 T capacity gondola car
	Rail rate to Waste Control Specialists	equipment	car trip	$ 7,825	5454	$ 42,675,052	MHF Services, email 3/13/14	per 110 T capacity gondola car, 1.2 T/CY
6.4	Transport by truck from mine site							
	Haul by truck and dump - WCS, Andrews, TX	labor,equipment	trip	$ 4,440	26312	$ 116,823,583	MHF Services, email 3/13/14	23 tons or 19 cy/trip
7	**Disposal at Licensed Facility**							
	Waste Control Specialists	fee	LCY	$ 200	499921	$ 99,984,148	Jeff Havlichak, WCS, 4/25/14	$200/cy, est 1.2 T/cy
8	**Site Restoration**							
	Final grading	labor,equipment	acre	$ 774.40	111	$ 85,958	RSM 2014 31 22 16.10 3300	Grade fo drainage and revegetation
	Revegetation - seeding with mulch and fertilizer	labor,equipment	acre	$ 938.28	111	$ 104,149	RSM 2014 32 92 19.14 5300	Drll seeding with mulch and fertilizer
9	**Post-Removal Site Controls**							
	Annual Inspections and Reports	labor	Yr	$ 1,714.00	12	$ 20,568	RSM 2014 01 13 13.20	one trip per year, scientist and technician for two days
TOTAL DIRECT COST				By Rail		**$ 151,219,022**		
				By Truck		**$ 220,850,593**		

Estimated duration of construction = 12 months 52.0 weeks 365 days, two 6-month work periods separated by 6 months

Waste volume for removal. Based on clean-up to 3.5 pCi/g Ra-226, is 318,502 m^3 or 416,601 CY bank volume; or ~500,000 LCY
Time-based work assumes half the waste volume is removed in each of two consecutive years
LCY = BCY x 1.2
1 CY = 1.5 T

JOHNNY M MINE EECA REMOVAL ALTERNATIVES COST ESTIMATE

CONSOLIDATION AND DISPOSAL ON-SITE ALTERNATVE

Removal to 3.5 pCi/g Residential Use Criterion

11/10/2014

Item #	Description	Material(s)	Units	$/Unit	Quantity	Cost, $	Cost Reference	Quantity Reference
	Direct Reclamation Costs							
1	**Mobilization/ Demobilization - Construction Contractor**	labor, equipment	1	3% of other direct	1	$ 147,206	NM MMD Financial Assurance Guidebook	(3% of other total on-site direct)
2	**Worker Health and Safety**							
2.1	RSO, full-time	labor	hrs	$ 130	1213	$ 157,733	ERG	full time for 7 months, 50 hrs/wk, 1213 hrs
2.2	Technician	labor	hrs	$ 80	607	$ 48,533	ERG	half time for 7 months, 50 hrs/wk, 607 hrs
3	**Radiological Surveying, Sampling and Testing**							
3.1	Mobilization/ Demobilization	labor, equipment	lump sum	$ 2,000	1	$ 2,000	ERG	
3.2	Remediation support surveys	labor, equipment	hrs	$ 80	1213	$ 97,067	ERG	item 4.3
3.3	Field gamma surveying	labor, equipment	lump sum	$ 40,000	1	$ 40,000	ERG	
3.4	Soil sample testing	contract lab	each	$ 130	1380	$ 179,400	ERG	Estimate based on 2000 m^2 SU segments for residential use (assumed), 10000 m^2 for industrial use. Table 4-26 SIR for areas and volumes.
4	**Construction Management**							
4.1	Construction superintendent	labor	wk	$ 2,050	30.3	$ 62,183	RSM 2014 01 31 13.20 0240	full time for 7 months, 50 hrs/wk, 1515 hours
4.2	Field engineer	labor	wk	$ 1,350	30.3	$ 40,950	RSM 2014 01 31 13.20 0120	full time for 7 months, 50 hrs/wk, 1515 hours
4.3	Ground control and volumetrics surveying	labor, equipment	day	$ 802	106	$ 85,380	RSM 2014 01 71 23.13 1100	half itme
4.4	Field lab operations for soil testing	labor, equipment	wk	$ 1,025	8	$ 7,773	RSM 2014 01 31 13.20 0100	one-third time
4.5	Field QC technicians for soil liner/cover	labor	wk	$ 1,025	15	$ 15,546	RSM 2014 01 31 13.20 0100	one-third time
4.6	QC records and reports clerk	labor	wk	$ 435	30.3	$ 13,195	RSM 2014 01 31 13.20 0020	full time for 7 months, 50 hrs/wk, 1515 hours
4.7	Field Office - 32' x 8' unit and 20' x 8' unit, furnished; 2 portable toilets	equipment	month	$ 1,171	7	$ 8,197	RSM 2014 01 52 32.20; 01 52 13 40; 01 54 33 40 6410	
4.8	Truck and equipment pressure washer	labor, equipment	month	$ 540	7	$ 3,780	RSM 2014 01 54 33 40 5460	
4.9	Dust control	labor, equipment	day	$ 1,625	213	$ 345,990	RSM 2014 31 23.23.20 2510	
5	**Clearing of Vegetation**	labor, equipment	acre	$ 252	125	$ 31,438	RSM 2014 31 13 13.10 0550	SIR Table 4-26 and Figure 4-33
6	**Removal of Contaminated Mine-Related Materials**							
6.1	Excavation of contaminated soil and mine waste rock							
	by scraper, 5000 ft haul	labor,equipment	BCY	$ 5.26	28139	$ 148,011	RSM 2014 31 23 16.50 2440; Caterpillar Performance Handbook	CAT 621;
	by scraper, 3000 ft haul	labor,equipment	BCY	$ 4.31	59276	$ 255,479	RSM 2014 31 23 16.50 2430; Caterpillar Performance Handbook	CAT 621
	by scraper, 1500 ft haul	labor,equipment	BCY	$ 3.32	129835	$ 431,051	RSM 2014 31 23 16.50 2420; Caterpillar Performance Handbook	CAT 621
	by excavator and truck, 0.5 m.i RT	labor,equipment	BCY	$ 4.13	23054	$ 95,211	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4014; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
	by excavator and truck, 1.0 mi. RT	labor,equipment	BCY	$ 4.35	173428	$ 754,411	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4016; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
	by excavator and truck, 2.0 mi. RT	labor,equipment	BCY	$ 4.75	2870	$ 13,631	RSM 2014 31 23 16.13 1030; RSM 21 23 23.20 4018; Caterpillar Performance Handbook	CAT 350 with 3 cy bucket, CAT D300E with 20 cy capacity
6.2	Spread and compact in repository location	labor, equipment	LCY	$ 1.48	499921	$ 739,883	RSM 2014 31 23 16.46 6006; Caterpillar Performance Handbook	CAT D10, < 100 ft push; SIR Table 4-26
7	**Construction of Repository**							Cover area is 11 acres
7.1	Excavation of soil for liner and cover							
	Rip shale	labor, equipment	BCY	$ 1.63	58817	$ 95,872	RSM 2014 31 23 16.32 2200	CAT D8 with ripper;
	Disc and windrow shale	labor, equipment	BCY	$ 2.05	58817	$ 120,576	RSM 2014 31 23 16.32 3200	CAT D8 short push
	Load, haul, and place reworked shale	labor, equipment	LCY	$ 3.58	70581	$ 252,680	RSM 2014 31 23 16.50 2300; Caterpillar Performance Handbook	CAT 621, 1500 ft ave.
7.2	Moisture conditioning of shale clay	labor, equipment	LCY	$ 1.50	70581	$ 105,871	RSM 2014 31 23 23.23 9030	6000 gal water truck, 1/2 mile haul
7.3	Spread and compact - clay liner	labor, equipment	LCY	$ 1.01	29093	$ 29,384	RSM 2014 31 23 23.23 5620	CAT 825C sheepsfoot w/ blade, 3 passes
7.4	Spread and compact - low permeability layer of cover	labor, equipment	LCY	$ 1.01	41488	$ 41,903	RSM 2014 31 23 23.23 5621	CAT 825C sheepsfoot w/ blade, 3 passes
7.5	Excavation of sandy soil for evapotranspiration layer of cover	labor, equipment	BCY	$ 3.32	293089	$ 116,767	RSM 2014 31 23 16.50 2300; Caterpillar Performance Handbook	Excavate, load, haul and place with CAT 621 scrapers; 1500 ft ave.
7.6	Spread and compact - evapotranspiration layer	labor, equipment	LCY	$ 1.48	35171	$ 52,053	RSM 2014 31 23 16.46 6006; Caterpillar Performance Handbook	CAT D10 short push;
8	**Erosion Protection**							Cover area is 11 acres
8.1	Rock fragmentation							
	Ripping sandstone	labor, equipment	BCY	$ 4.06	11799	$ 47,902	RSM 2014 31 23 16.32 1600	CAT D8 with ripper; assume 30% loss from intact volume
	Drilling and blasting	labor, equipment	BCY	$ 11.81	0	$ -	RSM 2014 31 23 16.30 0100	only for resistant rock, not rippable
8.2	Crushing	labor, equipment	BCY	$ 1.67	11799	$ 19,750	MB America Robbett Eyler, pers comm Nov 2013; RSM 2014 31 23 16.42 0300	MB America BF90 crusher bucket on CAT 320 excavator, minus 4 inches at 46 CY/hr
8.3	Screening	labor, equipment	Day	$ 1,424	67.42	$ 95,974	RSM 2014 01 54 33 3710; crew A-3C	150-200 CY/day
8.4	Load, haul and dump	labor, equipment	LCY	$ 3.19	15338	$ 48,928	RSM 2014 31 23 16.42 1601; RSM 2014 31 23 23.20 0026	CAT 980, 8 CY trucks, 0.5 mi RT
8.5	Riprap placement by machine							
	Channel riprap	labor, equipment	CY	$ 149	444	$ 66,222	RSM 31 37 13.10 0200	Machine placed, up to 1.5 ft thick
	Slope riprap/ rock mulch	labor, equipment	CY	$ 27.52	8631	$ 237,534	RSM 31 37 13.10 0300	Placed on slope for rock mulch or spreading in finish grading
9	**Site Restoration**							
9.1	Final grading	labor, equipment	acre	$ 774.40	125	$ 96,800	RSM 2014 31 22 16.10 3300	Grade all disturbed ground for drainage and revegetation
9.2	Revegetation							
	Mulch	labor, equipment	acre	$ 2,427	125	$ 303,395	RSM 2014 32 91 13.16 0350	hay straw mulch, power mulcher
	Seeding	labor, equipment	acre	$ 938.28	125	$ 117,285	RSM 2014 32 92 19.14 5300	tractor spreader
9.3	Fencing	labor, equipment	LF	$ 0.27	3000	$ 5,865	RSM 2014 32 31 26.20 0015; 32 31 13.40 2360	three strand barbed wire w/ one gate, 3400 ft.
10	**Post-Removal Site Controls**							
10.1	Annual Inspections and Reports	labor	Yr	$ 1,714	12	$ 20,568	RSM 2014 01 13 13.20	one trip per year, scientist and technician for two days
10.2	Repair and maintenance	labor, equipment	Day	$ 1,447.32	24	$ 34,736	RSM 2014 Crew B-11C	two person crew with backhoe loader for light repairs, two days annually
TOTAL DIRECT COST						**$ 5,634,113**		

Estimated duration of construction = 7 months 30.3 weeks 213 days

Waste volume for removal based on clean-up to 3.5 pCi/g Ra-226, is 317,183 m^3 or 414875 BCY. All of this volume is removed and placed in the C North repository.
Repostory surface area is: 10.9 acres 474,804 sq ft
LCY = BCY x 1.2